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NEW COLORADO APHIDIDÆ.

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This paper deals with 16 apparently new species of aphids taken in Colorado, and belonging to the tribes *Callipterini* and *Aphidini* as far as the subtribe *Macrosiphina*.

Plocamaphis braggii, n. sp.*

Fundatrix.—Described from type specimen taken on root of *Salix* sp., at Boulder, Colorado, May 17, 1918, by L. C. Bragg.

Color: Head, pro- and mesothorax, cauda and anal plate dark dusky brown to blackish; rest of dorsum sordid tan, mottled with ferruginous; antennæ and legs dusky-brown throughout; cornicles concolorous with body.

Measurements: Body, 2.7 mm. by 1.5 mm.; hind tibiæ, 1.27 mm.; antennæ, 1.50 mm.; joints as follows: III, .42 mm.; IV, .23 mm.; V, .22 mm.; VI, .17 + .28 mm.; cornicles, .05 mm.; cauda, .13 mm.

Structural characters: Apterous; secondary sensoria present on antennal joint III only, 5 in number; all other characters as in apterous viviparous female.

Apterous Summer Viviparous Female.—(Plate I, Fig. 1; Plate II, Figs. 1 and 2). Described from type and 2 paratype specimens taken on root of *Salix* sp., at Boulder, Colorado, September 7, 1917, by L. C. Bragg.

Color: Body dusky-brown with blackish lateral spots on each somite, intersegmental areas lighter and slightly powdery, especially toward anterior and posterior portions of body; antennæ dark dusky-brown on proximal and distal joints, lighter in middle portion; legs sordid yellowish-brown, with distal one-half or two-thirds of femora dusky-brown, and tarsi and tips of tibiæ black or blackish.

Measurements: Body, 2.50 to 3 mm. by 1.5 mm.; hind tibiæ, 1.55 mm. (1.50 to 1.80 mm.); antennæ, 1.80 mm. (1.50 to 1.90 mm.); joints as follows: III, .43 mm. (.43 to .50 mm.); IV, .27 mm. (.25 to

*Measurements in parentheses mean limits of variation found in paratypes.

.27 mm.); V, .29 mm. (.29 to .32 mm.); VI, .16 mm. (.16 to .18 mm.) + .40 mm. (.39 to .41 mm.); cornicles, .05 mm.; cauda, .15 mm.*

Structural characters: Secondary sensoria on antennal joint III only, 4 to 6 in number, small and arranged in an irregular row on posterior side of joint; hairs on body pointed, fine, .06 to .08 mm. long, quite numerous; on antennæ similar, .05 mm. long, numerous; same on cauda; cornicles inconspicuous, found only on close observation, slender, curved, smaller at distal end, .05 mm. in length, imbricated, without flanges; cauda inconspicuous, .07 mm. long, semicircular; frontal tubercles absent; lateral tubercles conspicuous on all abdominal segments except the 8th; ocular tubercles present but inconspicuous.

Alate Viviparous Female.—(Plate I, Fig. 2; Plate II, Figs. 3 and 4). Described from 4 specimens, one type and 3 paratypes taken on *Salix* sp., at Boulder, Colorado, September 7, 1917, by L. C. Bragg.

Color: Head and thorax black or blackish; abdomen yellowish-dusky-brown; antennæ dusky-brownish throughout; legs same color with distal half of femora, tips of tibiæ and entire tarsi black or blackish; cauda concolorous with body; stigmas yellowish-brown.

Measurements: Body, 3 mm. long; hind tibiæ, 1.6 mm. (1.4 to 1.65 mm.); antennæ, 1.8 mm. (1.70 to 1.90 mm.); joints as follows: III, .46 mm. (.41 to .47 mm.); IV, .28 mm. (.25 to .32 mm.); V, .32 mm. (.30 to .33 mm.); VI, .18 mm. + .32 mm. (.30 to .41 mm.); cornicles, .06 mm.; cauda, .15 mm., not projecting as far as the anal plate.

Structural characters: Secondary sensoria on joint III only, 10 to 14 in number in irregular row on posterior side of joint; fore wings with mediæ but once branched; hind wings with 2 cross veins; all other characters as in apterous viviparous female described above.

Male.—(Plate I, Fig. 3; Plate II, Fig. 8). Described from a single specimen taken on *Salix* in Fort Collins, Colorado, October 18, 1917, by L. C. Bragg.

Color: Entire dorsum yellowish-brown, shading into darker brown on head; antennæ pale dusky-brown; legs same color, except distal halves of femora, tips of tibiæ and entire tarsi, which are dusky to black; cornicles and cauda concolorous with body.

Measurements: Body, 2.3 mm.; hind tibiæ, 1.2 mm.; antennæ, 1.6 mm.; joints as follows: III, .40 mm.; IV, .22 to .30 mm.; V, .30 mm.; VI, .20 + .28 mm.

Structural characters: Apterous; secondary sensoria on antennal joint III, 14 to 17; IV, 6 to 7; V, 3 to 4; all other characters as in apterous viviparous female.

Oviparous Female.—(Plate I, Fig. 4; Plate II, Figs. 5, 6 and 7). Described from type specimen and one paratype taken on *Salix* sp., at Boulder, Colorado, November 5, 1917, by L. C. Bragg.

Color: Entire dorsum dark brown; antennæ and legs pale brownish-yellow; tarsi and distal parts of femora and tibiæ dusky to black; venter of abdominal segments 6, 7 and 8 bearing short wax filaments.

Measurements: Body, 3 mm., rather elongate; hind tibiæ, 1.7 mm.; antennæ, 1.7 mm.; joints as follows: III, .47 mm. (.47 to .55 mm.);

*Measurements given for cauda include both hard and soft portions.

IV, .27 mm. (.25 to .42 mm.); V, .29 mm. (.29 to .37 mm.); VI, .18 mm. (.17 to .24 mm.) + .35 mm. (.29 to .37 mm.); cornicles, .06 mm.

Structural characters: Apterous; all characters same as in apterous viviparous female, except hind tibiae, which are very slightly swollen and bear about 30 small, highly convex sensoria scattered along two-thirds of length.

Collections were taken on *Salix* sp. (root) by L. C. Bragg, all at Boulder, Colorado, except one at Fort Collins, Colorado.

Fundatrix.—One collection, May 17.

Apterous Viviparous Female.—Two collections, September 7 and 22.

Alate Viviparous Female.—One collection, September 7.

Male.—Two collections, October 18 and November 5.

Oviparous Female.—Three collections, September 22 to November 5.

Types in collection of the United States National Museum (Slide No. 41453); paratypes in Colorado Agricultural Experiment Station collection.

This species has been placed in the genus *Plocamaphis* only tentatively. It approaches also the genera *Melanoxantharium* and *Fullawayia*, but differs from all three in the absence of the second fork of the media. It differs from *Plocamaphis* in the lack of distinct flocculence, from *Melanoxantharium* in the absence of a flange on the cornicle, and from *Fullawayia* in the presence of minute cornicles. We hesitate, however, to erect a new genus on no other characters than the forking of the media and the absence of distinct flocculence.

Anuraphis ornata, n. sp.

Apterous Summer Viviparous Female.—(Plate I, Fig. 6; Plate II, Figs. 23 and 24). Described from one type and 4 paratype specimens taken on *Chrysothamnus graveolens*, at Fort Collins, Colorado, August 1, 1911, by L. C. Bragg.

Color: Dorsum of head dusky-brown, ground-color over rest of body, pinkish or flesh-color with transverse dashes of dusky on all segments, coalescing on 4th and 5th abdominal segments, and covering almost entire pronotum, reduced on 6th, 7th and 8th abdominal segments; dusky spots evident on lateral margins; entire dorsum covered with faint, white reticulations; cornicles, cauda and anal plate dusky to black; antennae pale yellowish except the 1st, 2nd, 5th and 6th joints, which are dusky; legs pale yellowish, with tarsi, tips of tibiae and distal half of femora dusky.

Measurements: Body, 1.5 mm. by 1.9 mm.; hind tibiae, .66 mm.; antennae, .90 mm.; joints as follows: III, .18 mm. (.12 to .20 mm.); IV, .10 mm. (.10 to .11 mm.); V, .10 mm. (.10 to .13 mm.); VI, .09 mm. + .12 mm. (.10 to .15 mm.); cornicles, .12 mm. (.10 to .12 mm.); cauda, .11 mm.

Structural characters: Secondary sensoria on joint III, 2 (1 to 2); on IV, 1; hairs on body fine, pointed, .03 to .05 mm., sparse and incon-

spicuous; similar on antennæ and legs; on cauda, .05 mm. and 4 to 5 in number on each side; cornicles cylindrical, slightly tapering distally, with slight flange, imbricated; frontal tubercles absent; lateral and ocular tubercles present.

Young.—(2nd instar). (Plate I, Fig. 7). Described from young born from apterous viviparæ described above.

Color: Entire dorsum pinkish, slightly dusky on head and slightly darker along median line of abdomen, perhaps from internal organs; antennæ and legs pale yellowish except tips, which are dusky. Length of body at this stage about 1 mm.

Alate Viviparous Female.—(Plate I, Fig. 5; Plate II, Figs. 20, 21 and 22). Described from one type and two paratypes taken on *Chrysothamnus graveolens* at Fort Collins, Colorado, August 28, 1917, by L. C. Bragg.

Color: Dorsum of head and thorax dark brown to black; abdomen yellowish-brown with dusky dashes on median and lateral portions of each segment; cauda concolorous with body; legs pale except the tarsi, tips of tibiæ and distal half of femora, which are dusky to black; antennæ blackish, except proximal part of joint III; cornicles dusky; stigmas dusky-yellowish.

Measurements: Body, 1.8 mm.; hind tibiæ, .66 to .70 mm.; antennæ, .80 to .86 mm.; joints as follows: III, .25 mm. (.22 to .29 mm.); IV, .13 mm. (.12 to .16 mm.); V, .13 mm. (.12 to .16 mm.); VI, .11 mm. + .14 mm. (.14 to .21 mm.); cornicles, .11 mm. (.10 to .12 mm.); cauda, .13 mm.

Structural characters: Secondary sensoria on joint III, 10 (7 to 10) in number; on IV, 1 (1 to 2) near distal end; all other characters as in apterous viviparæ; fore wings with mediæ twice branched; hind wings with 2 cross veins.

Male.—(Plate II, Fig. 25). Described from type taken October 22, 1914, and one paratype taken October 20, 1914, on *Chrysothamnus graveolens* at Fort Collins, Colorado, by L. C. Bragg.

Color: Impossible to determine, as specimens are mounted in balsam.

Measurements: Body, .85 to .90 mm.; hind tibiæ, .41 mm.; antennæ, .65 to .70 mm.; joints as follows: III, .18 mm.; IV, .09 mm.; V, .11 mm.; VI, .10 + .15 mm.; cornicles, .06 mm.; cauda, .05 mm.

Structural characters: Apterous; secondary sensoria on antennæ as follows: On III, 9; IV, 7 (3 to 8); V, 2 (2 to 5); VI, 3 (0 to 3); all other characters as in apterous viviparous female.

Oviparous Female.—(Plate II, Figs. 26, 27 and 28). Described from type taken on *Chrysothamnus graveolens* at La Porte (near Fort Collins), Colorado, November 8, 1916, by L. C. Bragg.

Color: Not determined, as specimen was mounted.

Measurements: Body, 1.80 mm.; hind tibiæ, .55 mm.; antennæ, .70 mm.; joints as follows: III, .18 mm.; IV, .09 mm.; V, .10 mm.; VI, .10 + .10 mm.; cornicles, .07 mm.; cauda, .07 mm.

Structural characters: Apterous; secondary sensoria absent on antennæ, a few large ones scattered over three-fourths of hind tibiæ; other characters as in viviparous female.

Collections were taken on *Chrysothamnus graveolens* and once on *Ratibida columnaris*, by L. C. Bragg, C. R. Jones, F. C. Hottes and the authors, mostly in the vicinity of Fort Collins, but also at Boulder and various localities quite widely distributed on the western slope of Colorado.

Fundatrix.—Not taken.

Apterous Viviparous Female.—Twenty-three collections, June 2 to October 20.

Alate Viviparous Female.—Ten collections, June 16 to August 28.

Male.—Two collections, October 11 to November 8.

Oviparous Female.—Three collections, October 11 to November 8.

Types in collection of the United States National Museum (Slide No. 41454); paratypes in collection of Colorado Agricultural Experiment Station.

This species is separated from *A. chrysothamnicola*, n. sp., by the color marking of the apterous viviparæ, the color of the young, the shape and length of the cornicles, the number of secondary sensoria, and the difference in size of the two forms.

***Anuraphis chrysothamnicola*, n. sp.**

Apterous Summer Viviparous Female.—(Plate I, Fig. 10; Plate II, Figs. 9, 11 and 13).

Described from type specimen taken on *Chrysothamnus* sp. at Pueblo, Colorado, June 15, 1909, by E. Bethel, and 3 paratypes taken on *Chrysothamnus graveolens* near Fort Collins, Colorado, August 27, 1917, by L. C. Bragg.

Color: Dusky ocher-red on dorsum, lighter laterally, covered with delicate white reticulation; cauda concolorous with body; legs pale yellowish with femora dusky and tips of tibiae and entire tarsi black; antennæ pale except first joint, tip of fifth, and entire sixth, which are dusky to black; cornicles dusky to black; eyes dark reddish brown.

Measurements: Body, 2 mm. by 1.3 mm.; hind tibiae, 1 mm. (.85 to 1 mm.); antennæ, 1.26 mm.; joints: III, .34 mm. (.23 to .34 mm.); IV, .30 mm. (.22 to .28 mm.); V, .22 mm. (.19 to .22 mm.); VI, .12 mm. + .22 mm. (.21 to .24 mm.); cornicles, .22 mm. (.16 to .22 mm.); cauda, .11 mm.

Structural characters: Secondary sensoria none; hairs on body pointed, sparse, .03 to .04 mm. long; on antennæ similar, rather frequent and nearly erect; on legs same as on antennæ; on cauda curved, pointed, 3 to 4 on each side and 1 or 2 on dorsal part; cornicles occasionally showing a small hair on proximal half. Cornicles imbricated, cylindrical, slightly enlarged toward proximal ends, without evident flanges; cauda triangular, rather acute; frontal tubercles absent; lateral tubercles present on prothorax and first and seventh abdominal segments; ocular tubercles present.

Young, early instar. — (Plate I, Fig. 11). Described from examples born from apterous viviparous female paratypes described above.

Color: Dorsum pale greenish with darker green area, later tinged with reddish, on segments 1 to 5 of abdomen; vertex and cauda dusky; legs colorless with tarsi dusky to black; antennæ pale with dusky tips.

Alate Viviparous Female.—(Plate I, Fig. 12; Plate II, Figs. 10, 12 and 14). Described from one type and four paratypes taken on *Chrysothamnus graveolens* near Fort Collins, Colorado, June 9, 1915, by L. C. Bragg.

Color: Head and thorax black; abdomen dull blackish-green, darker on median and segmental lines, and dashes on dorsum of segments 7 and 8; cauda concolorous with body; legs pale except distal two-thirds of femora, tips of tibiae and entire tarsi, which are dusky to black; antennae pale with entire joints 1, 2 and 6, and tips of 3, 4 and 5 dusky to black; cornicles dusky to black; stigmas dusky yellowish, veins heavy brown with faint dusky border.

Measurements: Body, 2 to 2.2 mm. long; hind tibiae, .90 to 1.00 mm.; antennae, 1 to 1.25 mm.; joints: III, .30 mm. (.22 to .30 mm.); IV, .25 mm. (.22 to .25 mm.); V, .20 mm. (.19 to .22 mm.); VI, .11 mm. + .21 mm. (.17 to .21 mm.); cornicles, .12 mm. (.11 to .16 mm.); cauda, .14 mm.

Structural characters: Secondary sensoria 4 (3 to 7) in a single row on joint III; cauda slightly more acute than in apterae; wings hyaline, mediae twice branched, hind wings with 2 cross veins. Other characters as in apterae.

Oviparous Female.—(Plate I, Fig. 8; Plate II, Figs. 15, 16 and 19). Described from 5 examples taken on *Chrysothamnus graveolens*, near Fort Collins, Colorado, October 12, 1914, by L. C. Bragg.

Color: Same as apterous viviparous female.

Measurements: Body, 2 mm.; hind tibiae, .60 mm. (.60 to .70 mm.); antennae, 1 mm.; joints: III, .23 mm. (.19 to .23 mm.); IV, .18 mm. (.15 to .19 mm.); V, .17 mm. (.14 to .17 mm.); VI, .10 mm. + .17 mm. (.16 to .20 mm.); cornicles, .09 mm. (.09 to .11 mm.).

Structural characters: Apterous; hind tibiae slightly swollen along entire length and with about 12 very inconspicuous sensoria scattered along inner surface. All other characters as in apterous viviparae.

Male.—(Plate I, Fig. 9; Plate II, Figs. 17 and 18). Described from type and paratype taken on *Chrysothamnus graveolens* near Fort Collins, Colorado, October 9, 1917, by L. C. Bragg.

Color: As in oviparae.

Measurements: Body, 1.25 to 1.50 mm.; hind tibiae, .70 mm.; antennae, 1 mm.; joints: III, .24 mm. (.21 mm.); IV, .18 mm. (.19 mm.); V, .17 mm. (.18 mm.); VI, .10 mm. + .15 mm. (.17 mm.); cornicles, .04 mm.

Structural characters: Apterous; secondary sensoria, 5 to 11 on antennal joint III, 6 to 7 on joint IV, and 5 to 6 on joint V. All other characters as in oviparae.

Collections all on *Chrysothamnus graveolens* near Fort Collins, Bellvue, Pueblo and Meeker, Colorado, by L. C. Bragg, F. C. Hottes, C. R. Jones, E. Bethel and the authors.

Apterous Viviparous Female.—Eighteen collections, from May 30 to September 24.

Alate Viviparous Female.—Six collections, from May 31 to July 10.

Oviparous Female.—Five collections, October 7 to October 29.

Male.—Four collections, October 9 to 29.

Types in collection of the United States National Museum (Slide No. 41455); paratypes in collection of Colorado Agricultural Experiment Station.

This species resembles *Aphis chrysothamni* Wil., but may be distinguished as follows: Absence of sensoria on joint IV of alate, the shorter cornicles, shorter antennal joint III, and longer unguis.

A closely related form was taken on *Chrysothamnus nauseosus* in Idaho. It differed in the presence of a distinct dark spot on the dorsum of the abdomen, which is apparent as a slightly dusky area even in the specimens mounted in balsam. The cornicles also are slightly longer than in the form above described. This form may constitute a distinct species.

***Anuraphis flocculosa*, n. sp.**

Apterous Summer Viviparous Female.—(Plate III, Fig. 1, Plate IV, Figs. 1, 5 and 6). Described from type taken on *Lonicera* sp., at Fort Collins, Colorado, June 6, 1916, and 12 paratypes taken on same host and same locality June 6 to 16, 1916, all by L. C. Bragg.

Color: Entire dorsum blackish-brown, shading to dull orange along lateral edges of thorax and at bases of cornicles; antennæ and legs pale yellowish-brown with dusky tips; cornicles yellowish-brown to dusky.

Measurements: Body, 2.75 mm.; hind tibiae, 1.30 mm. (1.20 to 1.50 mm.); antennæ, 2 mm. (1.90 to 2.40 mm.); joints as follows: III, .55 mm. (.50 to .68 mm.); IV, .33 mm. (.32 to .48 mm.); V, .30 mm. (.30 to .37 mm.); VI, .11 mm. (.11 to .15 mm.) + .45 mm. (.35 to .54 mm.); cornicles, .50 mm. (.50 to .68 mm.); cauda, .10 mm., broader than long.

Structural characters: Secondary sensoria on antennal joints small and round in shape; on joint III, 20 (10 to 20) in number, arranged in a very irregular double row along almost entire length of joint; on IV, 3 (0 to 3) on distal half of joint; hairs on body pointed, .04 mm. long, fine and sparse; on antennæ similar, .03 mm. long; on cauda slightly longer, curved and 3 on each side; cornicles marked with very fine transverse wrinkles difficult to see, and in mounted specimens appearing smooth, rather stout, broad at base, distinctly tapering towards distal end, with distinct flanges; frontal tubercles lacking; lateral tubercles weak; ocular tubercles present.

Alate Viviparous Female.—(Plate III, Fig. 2; Plate IV, Figs. 2, 3 and 4). Described from type taken on *Lonicera* sp., Fort Collins, Colorado, June 16, 1916, and 14 paratypes taken June 10 to 20, 1916, also one October 17, 1916, all on same host and in same locality, by L. C. Bragg.

Color: Head, thorax, cornicles, antennæ, femora, distal ends of tibiae and entire tarsi black; abdomen clay-colored, entire dorsum heavily covered with powdery secretion.

Measurements: Body, 2.30 mm. long; hind tibiae, 1.30 mm.; antennae, 2.2 mm.; joints as follows: III, .61 mm. (.58 to .77 mm.); IV, .40 mm. (.37 to .48 mm.); V, .33 mm. (.32 to .37 mm.); VI, .12 mm. + .52 mm. (.48 to .65 mm.); cornicles, .40 mm. (.39 to .46 mm.); cauda, .11 mm.

Structural characters: Secondary sensoria on antennae small, round and scattered, on joint III, about 40 in number; on IV, 8 (8 to 16); hairs and tubercles as in apterous viviparous female; cornicles cylindrical with flange; cauda longer and narrower than in apterae, about as broad as long; forewings with mediae twice branched; hind wings with 2 cross veins.

Oviparous Female.—(Plate IV, Figs. 8 and 9). Described from type and 3 paratypes taken on *Lonicera* sp., at Fort Collins, Colorado, November 15, 1916; 8 paratypes, November 17 and 24, 1916, and 6 others, October 28, 1914, all at Fort Collins, Colorado, by L. C. Bragg.

Color: Impossible to determine, as specimens were not observed until after mounting in balsam.

Measurements: Body, 3 mm.; hind tibiae, 1.30 mm. (1 mm. to 1.30 mm.); antennae, 1.85 mm. (1.40 to 2 mm.); joints as follows: III, .50 mm. (.40 to .56 mm.); IV, .33 mm. (.25 to .34 mm.); V, .30 mm. (.25 to .30 mm.); VI, .12 mm. + .44 mm. (.40 to .43 mm.); cornicles, .60 mm. (.40 to .60 mm.).

Structural characters: Secondary sensoria on antennal joint III only, 7 (3 to 8) in number; other characters as in apterous viviparous female, except hind tibiae, which are slightly swollen along entire length and thickly covered with sensoria of medium size.

Male.—(Plate IV, Fig. 7). Described from type taken at Fort Collins, Colorado, October 28, 1914, by L. C. Bragg.

Color: Not determined, as specimens are mounted in balsam.

Measurements: Body, 1.70 mm. long; hind tibiae, 1.40 mm.; antennae, 2.30 mm.; joints as follows: III, .65 mm.; IV, .49 mm.; V, .38 mm.; VI, .15 + .63 mm.; cornicles, .20 mm.; cauda, .08 mm.

Structural characters: Alate; secondary sensoria small, round and scattered throughout entire length of joints; on III, 42; IV, 21; V, 15 in number; all other characters as in alate viviparous female.

Collections were taken on *Lonicera* sp. at Fort Collins, Colorado, by L. C. Bragg.

Apterous Summer Viviparous Female.—Six collections, from June 6 to July 20.

Alate Viviparous Female.—Nine collections, from June 10 to October 28.

Oviparous Female.—Five collections, October 13 to November 24.

Male.—One collection, October 28.

Types in collection of the United States National Museum (Slide No. 41456); paratypes in collection of Colorado Agricultural Experiment Station.

This species is very peculiar on account of the unusually long cornicles and very short cauda, as well as the heavy pulverulence or flocculence.

*The slide containing this male and also six oviparous females is marked "*Symphoricarpos*," but this is probably an error, as all other records have been on *Lonicera*.

Anuraphis senecioradicis, n. sp.

Apterous Summer Viviparous Female.—(Plate III, Fig. 3; Plate IV, Figs. 11, 12 and 13). Described from type and 5 paratypes taken on root of *Senecio* sp. at Fort Collins, Colorado, September 4, 1918, also 4 paratypes taken August 29, 1918; 6 others, August 17, 1912, same host and locality as type, all by L. C. Bragg.

Color: Entire dorsum dusky blue-green, shading to brownish on head, covered with slight pulverulence; legs and antennæ dusky to blackish throughout; cornicles black.

Measurements: Body, 2.80 mm. by 1.70 mm.; hind tibiæ 1.05 mm.; antennæ, 1.25 mm.; joints as follows: III, .28 mm. (.26 to .31 mm.); IV, .22 mm. (.20 to .25 mm.); V, .20 mm. (.18 to .22 mm.); VI, .14 mm. (.14 to .18 mm.) + .27 mm. (.25 to .32 mm.); cornicles, .11 mm. (.10 to .14 mm.); cauda, .18 mm.

Structural characters: Secondary sensoria on antennal joints round, variable in size; on III, 5 (1 to 5) in number; IV, 5 (1 to 5); hairs fine, pointed, .04 to .05 mm. long, moderately numerous on body, antennæ and legs; hairs on cauda curved, .08 mm. long and 7 on each side; cornicle imbricated, cylindrical, without evident flange; cauda obtusely conical, with only a very slight suggestion of constriction; frontal tubercles lacking; lateral tubercles present on all segments anterior to cornicles, but not observed posteriorly; ocular tubercles present.

Alate Viviparous Female.—(Plate III, Fig. 4; Plate IV, Figs. 10 and 14). Described from type and 3 paratypes taken September 4, 1918, on root of *Senecio* sp., at Fort Collins, Colorado, also 14 paratypes taken August 29, 1918, 3 taken August 17, 1912, and one taken October 22, 1913, same host and locality, all by L. C. Bragg.

Color: Head and thorax black, dorsum of abdomen bluish-green, dusky on lateral areas of all segments and dusky dashes on dorsum of 7th and 8th; antennæ and legs dusky to black throughout.

Measurements: Body, 2.2 mm.; hind tibiæ, 1 mm. (.90 to 1.05 mm.); antennæ, 1.20 mm.; joints as follows: III, .25 mm. (.24 to .28 mm.); IV, .20 mm. (.19 to .23 mm.); V, .19 mm. (.15 to .20 mm.); VI, .14 mm. + .29 mm. (.24 to .32 mm.); cornicles, .10 mm. (.09 to .11 mm.); cauda, .14 mm.

Structural characters: Secondary sensoria on antennal joints round, medium in size, arranged in rather irregular row on posterior side of joints; on III, 5 (5 to 8); on IV, 4 (1 to 6); hairs, cornicles and tubercles as in apterous viviparous female; cauda similar to that of apterous, but slightly narrower; fore wings with mediæ twice forked; hind wings with two cross veins.

Male.—(Plate IV, Fig. 15). Described from type taken on root of *Senecio* sp., at Fort Collins, Colorado, by L. C. Bragg.

Color: Not determined, as specimen was not examined before mounting in balsam, but legs and antennæ still show dark coloration throughout.

Measurements: Body, 1.20 mm.; hind tibiæ, .70 mm.; antennæ, .90 mm.; joints as follows: III, .20 mm., almost completely coalesced

with IV; IV, .17 mm.; V, .15 mm.; VI, .10 mm. + .21 mm.; cornicles, .06 mm.; cauda, .09 mm.

Structural characters: Apterous; secondary sensoria on antennæ small and round and arranged in an irregular row on posterior side of joints, on III, 5; on IV, 4; on V, 3 or 4; hairs, cornicles, and tubercles as in apterous viviparous female.

Oviparous Female.—(Plate IV, Figs. 16 and 17). Described from type and 3 paratypes taken on root of *Senecio* sp., at Fort Collins, Colorado, October 22, 1913, by L. C. Bragg.

Color not determined before mounting in balsam, but legs and antennæ appear dark throughout.

Measurements: Body, 2.5 mm.; hind tibiæ, 1 mm.; antennæ, 1.25 mm.; joints as follows: III, .30 mm. (.25 to .30 mm.); IV, .16 mm. (.15 to .19 mm.); V, .16 mm. (.15 to .18 mm.); VI, .12 mm. + .26 mm.; cornicles, .10 mm. (.08 to .10 mm.).

Structural characters: Secondary sensoria on antennæ small and round, on III, 3; IV, 2; hind tibiæ slightly swollen beyond the middle, and bearing 13 sensoria (10 to 24); all other characters as in apterous viviparous form.

Collections were made on *Senecio* sp. and *Senecio spartioides*, at Fort Collins, Colorado Springs, Grand Mesa, northern Routt County, and Virginia Dale, Colorado, by L. C. Bragg and C. R. Jones.

Apterous Viviparous Female.—Ten collections, July 25 to September 21.

Alate Viviparous Female.—Five collections, August 16 to September 21.

Male.—One collection, October 30.

Oviparous Female.—One collection, October 30.

Types in collection of the United States National Museum (Slide No. 41457); paratypes in collection of Colorado Agricultural Experiment Station.

This species is separated from *A. lugentis* Will., which is also a dark green aphid on *Senecio* roots, by the much shorter cornicles, only one-half as long, the longer antennal filament, and the apterous condition of the male which is alate in *lugentis*.

It is separated from *A. senecio* Swain described without secondary sensoria in apteræ, pale green in color, and with about 22 sensoria on joint III of the antennæ in the alate form.

It differs from *A. middletonii* Thos. by the longer spur and cornicles.

Anuraphis debilicornis, n. sp.

Apterous Summer Viviparous Female.—(Plate IV, Figs. 20 and 21). Described from type and 4 paratypes taken on *Helianthus* sp. at Fort Collins, Colorado, July 20, 1912; also 6 other paratypes taken September 8, 1915, same host and locality, all by L. C. Bragg.

Color: Impossible to determine, as specimens are mounted in balsam.

Measurements: Body, 2 mm.; hind tibiae, 1 mm.; antennae, 1.10 mm.; joints as follows: III, .35 mm. (.26 to .35 mm.); IV, .17 mm. (.15 to .18 mm.); V, .16 mm. (.14 to .17 mm.); VI, .12 mm. + .17 mm. (.16 to .19 mm.); cornicles, .14 mm. (.10 to .14 mm.); cauda, .15 mm.; individuals without sensoria had shorter joints as follows: III, .20 to .26 mm.; IV, .13 to .16 mm.; V, .12 to .15 mm.; VI, .10 to .12 mm. + .14 to .19 mm.; cornicles, .08 to .10 mm.*

Structural characters: Secondary sensoria on antennae rather tuberculate and arranged in 2 irregular rows, on III, 15 (1 to 20); IV, 5 (1 to 5); some individuals lack secondary sensoria;* hairs fine, pointed, .05 mm. long, and sparse on body and antennae, more numerous on tibiae, .03 to .04 mm. long; on cauda, .07 mm. long, curved and 8 on a side; cornicles imbricated, cylindrical, and without flanges; frontal tubercles lacking; lateral tubercles present on prothorax, and 1st and 7th abdominal segments, ocular tubercles present; cauda bluntly conical without constriction.

Alate Viviparous Female. (Plate III, Fig. 6; Plate IV, Figs. 18, 19 and 27). Described from type and 4 paratypes taken on *Helianthus* at Fort Collins, Colorado, July 5, 1915, by L. C. Bragg.

Color: Head and thorax dull black, dorsum of abdomen and inter-segmental membranes on pronotum dark olive-buff to buffy-olive, marked with dusky on lateral areas of abdominal segments 2, 3 and 4, and slender dashes on dorsum of segments 7 and 8; cauda, cornicles and antennae dusky; legs dusky to black except proximal half to two-thirds of tibiae which are pale yellowish; stigmata pale brownish.

Measurements: Body, 2.60 mm.; hind tibiae, 1.10 mm.; antennae, 1.10 mm.; joints as follows: III, .35 mm.; IV, .18 mm.; V, .17 mm.; VI, .13 mm. + .19 mm.; cornicles, .10 mm.; cauda, .14 mm.

Structural characters: Secondary sensoria on antennae round and tuberculate, on III, 28 (20 to 30); IV, 7; V, 3 (1 to 3); hairs, cornicles and tubercles as in apterous viviparous form; cauda, slightly more elongate, but blunt and without evident constriction; fore wings with mediae twice branched; hind wings with two cross veins.

Male.—(Plate IV, Figs. 22 and 23). Described from type and 2 paratypes taken on *Helianthus annuus*, September 24, 1911, at Fort Collins, Colorado, and 3 paratypes taken on same host at Loveland, Colorado, all by L. C. Bragg.

Color: Not determined, as specimens are mounted in balsam.

Measurements: Body, 1.50 mm.; hind tibiae, .73 mm.; antennae, .95 mm.; joints as follows: III, .27 mm.; IV, .15 mm.; V, .14 mm.; VI, .11 mm. + .18 mm.; cornicles .05 mm.; cauda, .11 mm.

Structural characters: Alate; secondary sensoria on antennal joints small and round; on III, 36; on IV, 19; on V, 8 to 10; (on VI, 1 present in some paratypes); all other characters as in alate viviparous females.

*The individuals without sensoria were taken in the same collections with the others and appeared in all other respects to be the same species. These forms appeared in greatest numbers in late summer and fall collections, and quite rarely in spring and early summer, while the opposite was the case with the form with sensoria.

Oviparous Female.—(Plate III, Fig. 5; Plate IV, Figs. 24, 25 and 26). Described from type and 2 paratypes taken September 17, 1915, at Loveland, Colorado, also 3 others taken at Fort Collins, Colorado, September 24, 1911, on *Helianthus annuus*, all by L. C. Bragg.

Color: Entire dorsum dusky olive-green to brownish; antennæ dusky, except third joint which is pale; legs dusky except proximal two-thirds or three-quarters of 1st and 2nd pairs of tibiæ, which are pale yellowish, and same portions of hind tibiæ which are brownish; cornicles and cauda dusky.

Measurements: Body, 1.77 mm.; hind tibiæ .70 mm. (.65 to .80 mm.); antennæ, .87 mm.; joints as follows: III, .20 mm.; IV, .12 mm.; V, .12 mm.; VI, .11 mm. + .16 mm.; cornicles, .08 mm.; cauda, .15 mm.

Structural characters: Apterous; secondary sensoria absent on antennæ; hind tibiæ slightly swollen except on distal one-fourth, and bearing rather large convex sensoria scattered over entire swollen area; other characters as in apterous viviparous form.

Collections were taken on *Helianthus annuus* at Fort Collins and Loveland, Colorado, by L. C. Bragg.

Apterous Viviparous Female.—Seven collections, July 2 to September 26

Alate Viviparous Female.—Eight collections, July 5 to September 24.

Male.—Five collections, September 8 to 29.

Oviparous Female.—Three collections, September 17 to 29.

Types in collection of the United States National Museum (Slide No. 41458); paratypes in collection of Colorado Agricultural Experiment Station.

This species differs from *Aphis helianthi* Monell, according to metatype slides received from Monell, with which it has sometimes been confused, by the conical cauda, the much shorter cornicles, the much more numerous and more tuberculate sensoria on joint III of antenna, as well as presence of sensoria on joints IV and V of the alate viviparous female, and the presence of sensoria on antennæ of apterous viviparous females.

Siphonatrophia grvida* (Knowlton).

Fundatrix.—(Plate III, Fig. 7; Plate IV, Fig. 28). Described from type and 1 paratype taken on *Sabina scopulorum* at Fort Collins, Colorado, April 21, 1919, by L. C. Bragg.

* In preparing this paper this species was described as new, but after the manuscript was in the hands of the printer, we received from Professor Knowlton a separate of his paper in The Florida Entomologist on "A New Juniper Aphid from Utah." As Professor Knowlton's species seems to be identical with ours, we have accepted his specific name (*gravidis*), but have retained the generic name *Siphonatrophia*, and our discussion of the relation of our species to this genus. It might seem from Knowlton's description of wing venation that we were dealing with a different species, but two out of three cotypes which he sent us had the media twice forked in one wing and once forked in the other, indicating the variability of this character.

Color: Light cedar-green, tinged with dusky on head, shining; terminal joints of antennæ, tips of preceding joints, tarsi, and tips of tibiae dusky; remainder of antennæ and legs colorless; cauda pale greenish; cornicles concolorous with body.

Measurements: Body to base of cauda, 1.25 mm.; hind tibiae, .40 mm.; (.35 mm.); antennæ, .46 mm. (.40 mm.); joints as follows: III, .14 mm.; IV, .06 mm.; V, .10 mm. + .06 mm. (III, .15 mm.; IV, .09 mm. + .06 mm.); cornicles, mere rings or .01 mm.; cauda, .17 mm.

Structural characters: Apterous; dorsum highly arched, venter flattened; cauda directed ventrally; antennal joints III and IV were anastomosed in the type, and joints III, IV and V in the paratype; other characters as in apterous summer viviparæ.

Young.—(1st instar), (Plate III, Fig. 8). Described from examples born of fundatrices described above.

Entire dorsum pale yellowish-green; legs and antennæ colorless. Cauda, short, triangular, and dorsum not pronouncedly convex.

Apterous Summer Viviparous Female.—(Plate IV, Fig. 32). Described from type and 1 paratype taken May 9, 1919, by L. C. Bragg, and 8 others August 8, 1928, on *Sabina scopulorum* at Fort Collins, Colorado, by the junior author.

Color: Cedar-green, exactly imitating the cedar scales on which it feeds; shining paler green on head; tips of antennæ and tarsi slightly dusky, remainder of antennæ and legs colorless; cauda pale green; cornicles concolorous with body.

Measurements: Body to base of cauda, 1.40 mm. (1 mm.); hind tibiae, .40 mm.; antennæ, .60 mm.; joints as follows: III, .12 mm.; IV, .09 mm. (.06 to .09 mm.); V, .10 mm. (.08 to .11 mm.); VI, .10 mm. + .10 mm.; cornicles, .01 mm.; cauda, .17 mm.

Structural characters: Secondary sensoria absent on antennæ; hairs apparently absent on body and antennæ; on legs very short, .01 mm., and very sparse; on cauda, .03 mm. long, slightly curved and 5 or 6 on a side; cornicles mere pores on slightly raised base, .01 mm. high; cauda broad, long conical, rounded at tip, without constriction at base; frontal tubercles absent; lateral tubercles not evident; ocular tubercles present but inconspicuous.

Alate Viviparous Female.—(Plate III, Fig. 9; Plate IV, Figs. 29, 30 and 31). Described from type taken May 9, 1919, by L. C. Bragg, and 2 paratypes taken August 8, 1928, by the junior author all on *Sabina scopulorum* at Fort Collins, Colorado.

Color: Meso- and metathorax brown, rest of body cedar-green; legs and antennæ pale throughout, except tarsi and tips of tibiae which are tinged with dusky; cauda pale greenish; cornicles concolorous with body; stigmas pale.

Measurements: Body to base of cauda, 1.40 mm.; hind tibiae, .50 mm.; antennæ, .66 mm.; joints as follows: III, .20 mm.; IV, .10 mm.; V, .12 mm.; VI, .10 mm. + .12 mm.; cornicles .01 mm.; cauda, .17 mm.

Structural characters: Not arched dorsally as apterous; secondary sensoria on joint III, 6, round, and arranged in a single row; one small sensorium near tip of IV; fore wings with mediæ only once branched; hind wings with 2 cross veins; other characters as in apterous viviparæ.

Oviparous Female.—(Plate III, Figs. 10 and 11; Plate IV, Figs. 33 and 34). Described from type taken October 11, 1920, by senior author and 20 paratypes taken November 6, 1919, by L. C. Bragg, all on *Sabina scopulorum* at Fort Collins, Colorado.

Color: Same as in apterous viviparæ described above except hind tibiae, which are dusky throughout entire length.

Measurements: Body to base of cauda, 1.43 mm.; hind tibiae, .45 mm.; antennæ, .63 mm.; joints as follows: III, .16 mm. (.14 to .18 mm.); IV, .08 mm.; V, .10 mm.; VI, .09 mm. + .09 mm.; cornicles and cauda as in viviparæ.

Structural characters: Apterous, division between antennal joints III and IV, rather indistinct on antenna on one side, distinct on other antenna; a few paratypes with III and IV completely anastomosed; majority with division rather faint but evident; hind tibiae much swollen and thickly strewn with flat sensoria over almost entire length; other characters as in apterous viviparæ.

Egg.—(Plate III, Fig. 12). Described from eggs laid by oviparæ described above.

Color: Black, shining, some time after being laid. Measurements .66 mm. by .30 mm.

Apterous Male.—(Plate III, Fig. 13). Described from type taken in same collection as oviparæ paratypes.

Color: Impossible to determine as specimens are mounted in balsam; antennæ and legs appear dark throughout.

Measurements: Body to base of cauda, .95 mm.; hind tibiae, .48 mm.; antennæ, .70 mm.; joints as follows: III, .26 mm.; IV, .16 mm.; V, .14 mm.; VI, .07 mm. + .07 mm.; cauda, .11 mm.

Structural characters: Secondary sensoria on antennæ arranged in irregular row on posterior side of joints as follows: III, 10; IV, 8; V, 6; other characters as in apterous viviparæ.

Alate Male.—(Plate IV, Fig. 35). Described from type taken on *Sabina scopulorum*, at Fort Collins, Colorado, October 11, 1920, by the senior author, along with oviparous type.

Color: Impossible to determine as specimen is mounted in balsam; antennæ and legs appear dusky throughout.

Measurements: Same as apterous male.

Structural characters: Wings as in alate viviparæ, except that they are broader in proportion to their length, and in this single example at hand only one cross vein is visible in the hind wing. (Wings, however, are poorly mounted); antennæ as in apterous male; other characters as in alate viviparæ.

Collections, all on tips of twigs of *Sabina scopulorum*, at Fort Collins, Colorado, by L. C. Bragg and the authors, were made as follows:

Fundatrix.—One collection, April 21, 1919.

Apterous Summer Viviparous Female.—Three collections, May 9 to September 25.

Alate Viviparous Female.—Two collections, May 9 and August 8.

Oviparous Female.—Two collections, October 11 and November 6.

Apterous Male.—One collection, November 6.

Alate Male.—One collection, October 11.

+ .23 mm. (.18 to .25 mm.); cornicles .28 mm. (.22 to .30 mm.); cauda, .15 mm.

Structural characters: Antennæ without sensoria; hairs pointed, on body .05 mm. long, rather sparse; on antennæ and legs similar but fairly numerous; on cauda .06 to .07 mm., curved, 5 on each side; cornicles cylindrical or somewhat tapering, imbricated, with flanges, cauda blunt and parallel sided with slight constriction near base; frontal tubercles absent; lateral tubercles well developed; ocular tubercles present.

Two examples (Plate VI, Fig. 5a) taken in the same collection as the type bear 9 to 14 small, round, scattered sensoria on joint III of the antennæ, and one of them bears 2 on joint IV. Joint III measures .36 mm. in these examples, which is slightly longer than in the type and paratype. Otherwise no differences were noted to justify their determination as separate species.

Alate Viviparous Female.—(Plate V, Fig. 3; Plate VI Figs. 8 and 9). Described from type and 16 paratypes taken on *Frasera speciosa* near Bellvue, Colorado, June 13, 1916, by L. C. Bragg.

Color: Abdomen yellowish-green, mottled with darker green; head, thorax, cornicles, cauda, tarsi and tips of tibiae black; distal two-thirds of 2nd and 3rd pairs of tibiae, entire antennæ and lateral areas on all abdominal segments dusky to blackish; remainder of legs sordid honey-yellow; stigma pale dusky-yellow.

Measurements: Body, to base of cauda, 1.66 mm.; hind tibiae, .83 mm.; antennæ 1.12 mm.; joints as follows: III, .30 mm.; IV, .18 mm.; V, .17 mm.; VI, .13 mm. + .23 mm.; cornicles .20 mm.; cauda, .14 mm.

Structural characters: Secondary sensoria on antenna round, irregular in size and on III scattered over posterior half of joint, 24 in number; on IV, 1 to 7; fore wings with mediae twice branched; hind wings with two cross veins; other characters as in apterous viviparæ.

Collections were made on flower pedicels of *Frasera speciosa* in north central Colorado in altitudes from 6000 to 9000 feet, by L. C. Bragg and the authors as follows:

Apterous Summer Viviparous Female.—Nine collections, from May 28 to September 2.

Alate Viviparous Female.—Five collections, June 9 to August 12.

This is quite a common species. Types in collection of the United States National Museum (Slide No. 41460); paratypes in collection of Colorado Agricultural Experiment Station.

***Aphis cercocarpi*, n. sp.**

• *Apterous Summer Viviparous Female*.—(Plate V, Fig. 5; Plate VI, Figs. 10, 11 and 14). Described from type and one paratype taken on *Cercocarpus parvifolius* at Ingleside, Colorado, August 15, 1911, by L. C. Bragg, also about 20 other paratypes all taken on the same host, in distorted leaves at Loveland, Colorado, and hills* near Bellvue, Colorado, by L. C. Bragg, F. C. Hottes and the authors.

*Altitude 8,000 feet.

Color: Entire dorsum greenish-black, shining; antennæ and legs pale with tips of antennæ distal ends of femora and tibiæ and entire tarsi black or blackish; cornicles and cauda dark to black.

Measurements: Body, 1.30 mm. to base of cauda; hind tibiæ .70 mm.; antennæ, .95 mm.; joints as follows: III, .26 mm. (.20 to .30 mm.); IV, .17 mm. (.11 to .19 mm.); V, .14 mm. (.10 to .15 mm.); VI, .10 mm. + .20 mm. (.18 to .24 mm.); cornicles .16 mm. (.12 to .18 mm.); cauda .12 mm.

Structural characters: Secondary sensoria absent; hairs on body pointed, .03 mm. long, inconspicuous and sparse; same on antennæ, slightly more numerous on legs; on cauda curved, three on each side; cornicles cylindrical or slightly tapering, slightly imbricated, with distinct flanges; cauda rather globular in shape with distinct constriction near base; frontal tubercles lacking; lateral tubercles evident on prothorax and 1st and 7th abdominal segments; ocular tubercles present.

Alate viviparous Female.—(Plate V, Fig. 6; Plate VI, Figs. 12 and 13). Described from type taken on *Cercocarpus parvifolius* on hills near Bellvue,* Colorado, August 21, 1922, by F. C. Hottes, in distorted leaves.

Color: Head and thorax black; abdomen blackish-green; antennæ pale on proximal portions of joints III and IV, remainder dusky to black; legs pale with distal halves of femora dusky and tarsi and tips of tibiæ blackish; cornicles and cauda dusky; wing veins black; stigmas yellowish.

Measurements: Body, to base of cauda, 1.33 mm.; hind tibiæ, .67 mm.; antennæ, .85 mm.; joints as follows: III, .25 mm.; IV, .12 mm.; V, .12 mm.; VI, .10 mm. + .19 mm.; cornicles, .10 mm.; cauda, .08 mm.

Structural characters: Secondary sensoria on antennal joint III only, 17 in number, large, round and scattered over entire joint; fore wings with mediæ twice branched, second fork twice as far from first fork as from margin of wing; hind wings with two cross veins; all other characters as in apterous form.

Sexuales have not been taken.

Collections were all taken on *Cercocarpus parvifolius* in Larimer County in altitudes from 5000 to 8000 feet by L. C. Bragg, F. C. Hottes and the authors.

Apterous Viviparous Female.—Three collections, August 15 to 21.

Alate Viviparous Female.—One collection, August 21.

Types in collection of United States National Museum (Slides No. 41461); paratypes in collection of Colorado Agricultural Experiment Station.

***Aphis lupini*, n. sp.**

Fundatrix.—Described from a single specimen taken on *Lupinus decumbens* at Fort Collins, Colorado, May 22, 1918, by L. C. Bragg.

Color: Entire dorsum dull blackish-green shading to black on head; antennæ, legs, cornicles and cauda black throughout.

*Altitude 8,000 feet.

Measurements: Body to base of cauda 3 mm. by 2 mm.; hind tibiae 1 mm.; antennae 1.20 mm.; joints as follows: III and IV anastomosed, .47 mm.; V, .23 mm.; VI, .15 mm. + .18 mm.; cornicles, .21 mm.; cauda, .26 mm.

Structural characters as in apterous viviparae.

Although this specimen was taken rather late for a fundatrix and in company with evident summer generations, the shorter cornicles and antennae and the five-jointed condition of the antennae as well as the darker color of the individual make it seem almost certain to be a fundatrix.

Apterous Summer Viviparous Female.—(Plate V, Fig. 7; Plate VI, Figs. 15 and 19). Described from type taken on *Lupinus decumbens* at Boulder, Colorado, June 3, 1912, by L. C. Bragg, also 4 paratypes taken on same host, at Fort Collins, Colorado, May 13, 1916, by same collector.

Color: Entire dorsum dusky olive-green, shading to brownish on head; antennae pale shading to blackish toward tip, especially on distal ends of joints; legs dusky to black throughout except proximal portions of femora; cornicles and cauda black. In cleared or alcoholic specimens dark bands appear on 7th and 8th abdominal segments.

Measurements: Body to base of cauda, 2.10 mm. (2 to 3 mm.) by 1.10 to 1.80 mm.; hind tibiae, 1.10 mm.; antennae 1.50 mm.; joints as follows: III, .38 (.36 to .40 mm.); IV, .33 mm. (.25 to .33 mm.); V, .25 mm.; VI, .14 mm. + .25 mm.; cornicles .25 mm.; cauda, .28 mm.

Structural characters: Secondary sensoria on antennae lacking; hairs on body pointed, .03 mm. long, sparse and inconspicuous; similar on antennae and legs but more numerous; on cauda curved, 6 or 7 on each side; cornicles rather closely imbricated, cylindrical or slightly larger at bases, flanges present but inconspicuous, frontal tubercles short but distinct; lateral and ocular tubercles present; cauda acute conical, with only slight constriction.

Alate Viviparous Female.—(Plate V, Fig. 8; Plate VI, Figs. 16, 17 and 18). Described from type and three paratypes taken on *Lupinus* sp. at Boulder, Colorado, June 3, 1912, by L. C. Bragg, and one other taken on same host at Fort Collins, Colorado, May 15, 1916, by the same collector.

Color: Head and thorax coal black; abdomen greenish-black, antennae rather dusky throughout, except proximal portion of joint III; legs pale except femora, especially 2d and 3d pairs, which are dusky on distal portions, and tarsi and tips of tibiae which are black; cornicles and cauda dusky; wing veins rather heavy and black, stigmas dusky-yellowish.

Measurements: Body to base of cauda 2.25 mm.; hind tibiae 1.10 mm.; antennae 1.50 mm., joints as follows: III, .37 mm. (.35 to .38 mm.); IV, .30 mm. (.25 to .30 mm.); V, .27 mm. (.22 to .27 mm.); VI, .15 mm. + .25 mm.; cornicles .20 mm. (.19 to .23 mm.); cauda .20 mm.

Structural characters: Secondary sensoria round and arranged in a row on posterior side of joint III, 4 in number (3 to 6), absent on remaining joints; fore wings with mediae twice branched; hind wings with 2 cross veins; other characters as in apterous viviparae.

Collections were all taken on *Lupinus decumbens* at Fort Collins, Boulder and Bellvue*, Colorado, by L. C. Bragg and F. C. Hottes.

Fundatrix.—One collection, May 22.

Apterous Viviparous Female.—Eleven collections, May 13 to August 31.

Alate Viviparous Female.—Four collections, May 15 to July 6.

This is a common species in northern Colorado.

Types in collection of the United States National Museum (Slides No. 41462); paratypes in collection of Colorado Agricultural Experiment Station.

Aphis ribiensis, n. sp.

Fundatrix.—(Plate V, Fig. 9; Plate VI, Fig. 20). Described from type taken on *Ribes longiflorum*, at Fort Collins, Colorado, May 26, 1909, by the senior author.

Color: Entire dorsum pale yellowish-green, becoming lighter on head; cornicles and cauda nearly colorless; antennae colorless except distal two joints which are dusky to black; legs colorless except tarsi and distal ends of tibiae which are blackish.

Measurements: Body to base of cauda, 1.90 mm. by 1.10 mm.; hind tibiae .55 mm.; antennae .5+ mm.; joints as follows: III, .18 mm.; IV, .09 mm.; V, .08 mm. + .10 mm.; cornicles .11 mm.; cauda .14 mm.

Structural characters: Apterous; antennae five-jointed; all other characters as in apterous viviparae.

Apterous Viviparous Female.—(Plate VI, Figs. 21 and 22). Described from type and 5 paratypes taken on *Ribes longiflorum*, at Fort Collins, Colorado, May 26, 1909, by L. C. Bragg.

Color same as in fundatrix.

Measurements: Body to base of cauda, 1.80 mm. by 1 mm.; hind tibiae .85 mm.; antennae .95 mm.; joints as follows: III, .24 mm.; IV, .16 mm.; V, .15 mm.; VI, .11 mm. + .13 mm.; cornicles .20 mm.; cauda .19 mm.

Structural characters: Secondary sensoria absent on antennae; hairs on body pointed, .04 mm. long, very sparse and inconspicuous; on antennae slightly more numerous; on tibiae, .04 to .05 mm. long, rather numerous; on cauda, long curved, and 3 to 4 on a side; cornicles imbricated, cylindrical or slightly tapering in shape; cauda rather triangular with slight neck; frontal tubercles absent; lateral tubercles present; ocular tubercles present.

Pupa.—Abdomen yellowish-green; thorax much paler; head a little dusky; cornicles quite pale; wing pads black. Some individuals with very distinct mottling on dorsum as in pupae of *A. gossypii*.

Alate Viviparous Female.—(Plate V, Fig. 10; Plate VI, Figs. 23, 24 and 25). Described from type and 6 paratypes taken on *Ribes longiflorum*, November 3, 1910, at Fort Collins, Colorado, by L. C. Bragg.

Color: Head and thorax black; abdomen yellowish-green; antennae dusky, lighter on basal portion of joint III; legs pale ochre with tips black; cornicles and cauda pale; stigmas pale dusky-yellowish.

*In neighboring hills, altitude 8,000 feet.

Measurements: Body, to base of cauda, 1.65 mm.; hind tibiae, .80 mm.; antennae, .95 mm.; joints as follows: III, .26 mm.; IV, .15 mm.; V, .14 mm.; VI, .10 mm. + .22 mm.; cornicles .13 mm.; cauda, .17 mm.

Structural characters: Secondary sensoria on antennal joints rather large and round, arranged in irregular or partly double row on posterior side of joint III, 10 in number (9 to 12); IV, 5; hairs on body .02 mm. long, pointed fine, sparse and very inconspicuous; hairs on antennae similar to those on body; hairs on legs .02 to .03 mm., pointed and moderately numerous; hairs on cauda .05 mm. long, curved and 3 or 4 on each side; cornicles imbricated, cylindrical and with flange; cauda aphid-like with constriction near base; frontal tubercles lacking; lateral tubercles present; ocular tubercles distinct; fore wings with mediae twice branched, with second fork arising at a point two-thirds the distance from origin of first fork to margin of wing; hind wings with two cross veins.

Male.—(Plate V, Fig. 13; Plate VI, Figs. 26 and 27). Described from type and 6 paratypes taken November 2, 1910, and 8 paratypes taken October 26, 1910, all on *Ribes longiflorum* at Fort Collins, Colorado, by L. C. Bragg.

Color: Head and thorax black; abdomen dusky dark green; antennae black or blackish throughout; legs pale ochre-yellow with same parts black as in alate viviparae; cornicles and cauda dusky; stigmata greenish.

Measurements: Body, to base of cauda, 1.33 mm.; hind tibiae, .65 mm.; antennae, .85 mm.; joints as follows: III, .23 mm.; IV, .17 mm.; V, .15 mm.; VI, .10 mm. + .17 mm.; cornicles .08 mm.; cauda, .10 mm.

Structural characters: Alate, secondary sensoria as follows: on III, 22; on IV, 15; on VI, 6 (5 to 12); other characters as in alate vivipara.

Oviparous Female.—(Plate V, Fig. 11; Plate VI, Figs. 28, 29 and 30). Described from type and one paratype taken October 26, 1910, also two others taken November 2, 1910, all on *Ribes longiflorum* at Fort Collins, by L. C. Bragg.

Color: Entire dorsum pale yellowish to whitish; slightly brownish tinge on head; all appendages colorless or whitish, except tarsi, which are blackish, and tips of tibiae which are slightly dusky.

Measurements: Body, to base of cauda, 1.55 mm.; hind tibiae, .40 mm.; antennae, .55 mm.; joints as follows: III, .17 mm.; IV, .09 mm.; V, .08 mm. + .11 mm.; cornicles .08 mm.; cauda, .11 mm.

Structural characters: Apterous; secondary sensoria absent on antennae; sensoria on hind tibiae rather large and somewhat tuberculate, scattered over proximal two-thirds which are slightly swollen; other characters as in fundatrix; cauda sometimes rather broad as in Fig. 30a.

Egg.—(Plate V, Fig. 12) .55 mm. by .29 mm.; greenish yellow when first laid, turning to deep shining black later.

Collections were taken on *Ribes longiflorum* at Fort Collins, Colorado, by L. C. Bragg and the senior author. They are found on the tender shoots and terminal leaves which they cause to curl and form a sort of a rosette.

Fundatrix.—One collection, May 26.

Apterous Summer Viviparous Female.—One collection, May 26.

Alate Viviparous Female.—Six collections, May 31 to November 3.

Male.—Five collections, October 17 to November 2.

Oviparous Female.—Five collections, October 17 to November 2.

Types in collection of United States National Museum (Slides No. 41463); paratypes in collection of Colorado Agricultural Experiment Station.

This species occurs in same colonies with *Aphis varians* Patch (now *A. epilobii* Kittel (?)), but may be distinguished by the absence of sensoria on antennal joint IV of alata, by fewer hairs on cauda, 2 or 3 on a side in *ribiensis*, while *variens* has 6 on a side, also by difference in length of cornicles, .10 to .13 mm. in *ribiensis*, and about .20 mm. in *variens*. They differ also in color, *variens* being dark green while *ribiensis* is pale yellow-green.

Aphis asterensis, n. sp.

Apterous Summer Viviparous Female.—(Plate V, Fig. 14; Plate VIII, Figs. 1, 2 and 3). Described from type and 6 paratypes taken on *Aster multiflorus* taken at Fort Collins, Colorado, May 29, 1916, by L. C. Bragg, also two others taken May 8, 1916, with same data.

Color: Entire dorsum pale greenish-yellow, only tips of antennal joints III, IV and V, and entire joint VI, tarsi and tips of tibiae dusky to black; cornicles pale with slight dusky shade distally; cauda pale.

Measurements: Body to base of cauda, 1.30 mm.; hind tibiae, .60 mm.; antennae, .75 mm.; joints as follows: III, .22 mm. (.17 to .26 mm.) IV, .10 mm.; V, .08 mm.; VI, .09 mm. + .17 mm. (.14 to .20 mm.); cornicles .11 mm. (.11 to .15 mm.); cauda, .14 mm.

Structural characters: Secondary sensoria on antennal joints rather large, round and arranged in a row on posterior side of joint, on III, 2 or 3, on distal half; on IV, 0 on one antenna and 1 on the other at tip of joint; hairs on body capitate, .03 to .05 mm. long, three pairs of rows on dorsum of abdomen becoming shorter anteriorly, very minute or absent on thorax; on antenna capitate, .01 mm., very sparse and inconspicuous; on tibiae blunt, .01 to .05 mm. long, and fairly numerous; on cauda, 2 capitate hairs near tip, 2 curved, pointed hairs on each side; cornicles smooth, cylindrical, with rather broad flanges; cauda long, rather slender, irregular and approximately parallel sided distally, spreading at base; frontal tubercles lacking; lateral tubercles present, but difficult to observe in most of the specimens; ocular tubercles present.

Alate Viviparous Female.—(Plate V, Fig. 15; Plate VIII, Figs. 4, 5 and 6). Described from type taken on *Aster multiflorus* at Fort Collins, Colorado, May 9, 1916, by L. C. Bragg, also 4 paratypes taken May 29, 1916, with same data.

Color: Head and thorax yellowish-brown; abdomen light yellow mottled with pale green; antennae dusky to black throughout; legs

pale with distal halves of femora slightly dusky, extreme tips of tibiae blackish, entire tarsi black; cornicles slightly dusky, cauda pale, wing veins heavy and black; stigmas dusky-yellow.

Measurements: Body to base of cauda, 1.40 mm.; hind tibiae, .70 mm.; antennae, 1.10 mm.; joints as follows: III, .35 mm. (.33 to .40 mm.); IV, .15 mm.; V, .12 mm.; VI, .11 mm. + .23 mm.; cornicles, .14 mm. (.10 to .15 mm.); cauda, .14 mm.

Structural characters: Secondary sensoria on antennae large, round and irregular in size, scattered along entire joint, on III, 10 (10 to 14) in number; on IV, 4 on one antenna and 6 on the other; on V, 0 on left side and 1 on the right; fore wings with median twice branched, second fork varying considerably in size in hind wings with two cross veins.

Male.—(Plate VIII, Fig. 7). Described from type taken on *Aster multiflorus* at Fort Collins, Colorado, by L. C. Bragg.

Color: Not determined as specimen is mounted, but dusky markings appear in balsam to be the same as in alate viviparae.

Measurements: Body to base of cauda, .80 mm. (?); hind tibiae .55 mm.; antennae, .83 mm.; joints as follows: III, .30 mm.; IV, .14 mm.; V, .10 mm.; VI, .07 mm. + .20 mm.; cornicles .05 mm.

Structural characters: Alate; secondary sensoria on antennae round and rather tuberculate, on III, 22; on IV, 12; V, 4; all other characters as in alate viviparae.

Oviparous Female.—(Plate VIII, Figs. 8, 9 and 10). Described from type and 12 paratypes taken with male above described.

Color: Not determined as specimens are mounted.

Measurements: Body to base of cauda, 1.40 mm.; hind tibiae, .58 mm.; antennae .75 mm.; joints as follows: III, .25 mm.; IV, .09 mm.; V, .10 mm.; VI, .09 mm. + .19 mm.; cornicles .11 mm. (.11 to .14 mm.); cauda, .15 mm.

Structural characters: Apterous; all characters as in apterous viviparae except hind tibiae, which are noticeably swollen on proximal one-third and bear large, flat, irregular sensoria, 11 (8 to 16) in number.

Collections were taken all on *Aster multiflorus* at Fort Collins, Colorado, by L. C. Bragg.

Apterous Viviparous Female.—Three collections, May 8 to October 5.

Alate Viviparous Female.—Two collections, May 8 to May 29.

Male.—One collection, October 5.

Oviparous Female.—One collection, October 5.

Types in collection of United States National Museum (Slides No. 41464); paratypes in collection of Colorado Agricultural Experiment Station.

***Aphis pentstemonicola*, n. sp.**

Fundatrix.—(Plate VII, Fig. 1; Plate VIII, Figs. 11 and 12). Described from type and one paratype taken on *Pentstemon* sp. at Fort Collins, Colorado, April 23, 1919, by L. C. Bragg.

Color: Dorsum pale green, marked with dusky to black on head, dorso-lateral portions of pronotum, lateral areas of all segments, lateral spot on 6th abdominal segment extending mediad of cornicles, and

slight dorsal dashes on abdominal segments 7 and 8; antennae dusky to black, except proximal portion of joint III, which is pale; legs pale dusky to colorless except tarsi and tips of femora and tibiae which are black; cornicles and cauda black.

Measurements: Body to base of cauda, 1.73 mm.; hind tibiae, .72 mm.; antennae 1 mm.; joints as follows: III, .32 mm.; IV, .18 mm.; V, .14 mm.; VI, .12 mm. + .14 mm.; cornicles, .21 mm.; cauda .13 mm.

Structural characters: Apterous; secondary sensoria on antennae round, moderately large, arranged in irregular double rows; on III, 10; IV, 4; joints III and IV anastomosed on paratype and one side of type; all other characters as in apterous viviparous female.

Apterous Summer Viviparous Female:—

Young, 1st instar.—(Plate VII, Fig. 2). Described from individuals born from fundatrices described above.

Color: Entire dorsum pale green, with a pair of large dusky areas on head; antennae and legs pale grayish shading to darker at distal ends; cornicles and cauda dusky; young born from later generations showed dark green spot on dorsum of abdomen.

Adult.—(Plate VII, Fig. 4; Plate VIII, Figs. 13, 14 and 17). Described from type and one paratype taken June 7, 1915, also 2 paratypes, 2d generation, taken May 13, 1918, all on *Penstemon* sp., and by L. C. Bragg.

Color: Head, pro- and mesothorax, a pair of dashes on metathorax, lateral areas of all abdominal segments, and broad dorsal bands on abdominal segments 6, 7 and 8, black; remainder of dorsum light yellow mottled with bluish or dusky-green; antennae dusky to black, except extreme base of joint III, which is colorless; legs pale or colorless on proximal half to two-thirds of tibiae, remaining parts dusky to black; cornicles and cauda black.

Measurements: Body, to base of cauda, 2 mm.; hind tibiae 1. mm.; antennae, 1.30 mm.; joints as follows: III, .36 mm. (.31 to .40 mm.); IV, .27 mm. (.21 to .29 mm.); V, .22 mm. (.17 to .29 mm.); VI, .13 mm. + .26 mm. (.18 to .27 mm.); cornicles .30 mm. (.30 to .38 mm.); cauda, .14 mm.

Structural characters: Secondary sensoria* on antennal joint III, 20 (18 to 30); IV, 12 (8 to 15); V, 8 (2 to 8); hairs on body fine, pointed and fairly numerous to sparse, .04 to .05 mm in length; similar on antennae but slightly shorter and more numerous; same on legs as on

*The number of secondary sensoria on antennae in the apterae seems to be a rather unstable character in this species. Frequently individuals were observed which bore fewer sensoria more confined to distal end of joint III than the typical forms, and this smaller number of sensoria appeared to be correlated with shorter antennal joints. In one extreme case taken on *Penstemon* sp., at Boulder, Colo., August 15, 1912, by L. C. Bragg, a collection of 9 apterous specimens, numbers of secondary sensoria were as follows: III, 0 to 18; IV, 2 to 15; V, 0 to 9; lengths of antennal joints: III, .14 to .19 mm.; IV, .12 mm.; V, .10 to .12 mm.; VI, .08 mm. + .13 mm.; cornicles, .06 to .12 mm.; hind tibiae, .40 to .50 mm. The bodies in this lot were much smaller than the typical forms, suggesting perhaps a stunting due to starvation. Considering the intergrading and mingling of variations in the same colonies, there does not seem to be justification at present for the determination of these as distinct species. Further biological study is needed to settle the question definitely.

antennæ; on cauda curved, .07 mm. long and three on each side; cornicles rather faintly imbricated, cylindrical or slightly tapering, flanges present; cauda short, rather conical, with a slight constriction at base; frontal tubercles lacking; lateral tubercles evident on pronotum, first, sixth and seventh segments of abdomen, inconspicuous or missing on other segments; ocular tubercles present.

Alate Viviparous Female.—(Plate II, Fig. 3; Plate J, Figs. 15, 16 and 18). Described from a second-generation individual taken May 28, 1915, 10 paratypes taken May 1, 1916, 7 taken May 13 and 14, 1918, and 12 taken June 4 and 8, 1917, all on *Pentstemon* sp. at Fort Collins, Colorado, by L. C. Bragg.

Color: Head, thorax, lateral areas on abdominal segments 1 to 5, area posterior and medial to bases of cornicles, and slender dorsal dashes on abdominal segments 7 and 8 black; dorsum of abdomen pale green slightly mottled with darker green, cornicles and chitimized portion of cauda black; antennæ black except extreme base of joint III; legs pale sordid yellowish with dusky to black on distal portions of femora and tibiae, and entire tarsi; stignas sordid yellowish.

Measurements: Body to base of cauda, 1.80 mm.; hind tibiae, .85 mm. (.75 to .90 mm.); antennæ, 1.20 mm.; joints as follows: III, .33 mm. (.30 to .36 mm.); IV, .25 mm. (.20 to .25 mm.); V, .18 mm. (.17 to .20 mm.); VI, .12 mm. + .22 mm. (.17 to .24 mm.); cornicles, .20 mm. (.17 to .20 mm.); cauda, .12 mm.

Structural characters: Secondary sensoria* on antennæ round, convex, irregularly scattered over entire length of joints, on III, 36 (36 to 43); IV, 20 (15 to 20); V, 6 (5 to 9); hairs and tubercles as in apterous viviparous female; cornicles cylindrical, flanges present; cauda similar to that of aptere but slightly more slender; fore wings with mediae once forked; hind wings with 2 cross veins.

Male.—(Plate VII, Fig. 7, Plate VIII, Figs. 19, 20, 21). Described from type and 4 paratypes taken on *Pentstemon* sp. at Fort Collins, Colorado, October 19 and 20, 1916, by L. C. Bragg.

Color: Entire dorsum very dark olive-green; all appendages dark dusky-brown to black.

Measurements: Body, 1.10 mm.; hind tibiae, .40 mm.; antennæ, .70 mm.; joints as follows: III, .16 mm. (.16 to .19 mm.); IV, .13 mm. (.12 to .16 mm.); V, .12 mm. (.10 to .13 mm.); VI, .07 mm. + .13 mm.; cornicles, .05 mm.; cauda, .06 mm.

Structural characters: Apterous; secondary sensoria on antennæ small, round and scattered, on III, 12 (9 to 18); IV, 11 (11 to 20); V, 6 (6 to 9); all other characters as in apterous viviparous female.

Oviparous Female.—(Plate VII, Fig. 6; Plate VIII, Figs. 22, 23 and 24). Described from type and 3 paratypes taken on *Pentstemon* sp. at Fort Collins, Colorado, October 20, 1916, by L. C. Bragg.

*A considerably smaller number of sensoria on antennal joint III was found in 4 individuals taken with aptera mentioned in footnote for apterous viviparous form. Antennal joints were much shorter also. Numbers of sensoria are as follows: III, 20 to 24; IV, 12; V, 5 to 7. Lengths of joints: III, .20 to .24 mm.; IV, .14 mm.; V, .13 mm.; VI, .09 mm. + .19 mm.; cornicles, .08 mm.; hind tibiae, .45 mm. The bodies were very small also. No other characters were observed which would warrant a determination as a distinct species.

Color: Dorsum brownish-yellow shading to dusky-brown on head, mottled with dusky-green on dorsum of abdomen; antennæ dusky-brownish, darker on terminal joints; legs sordid water-white, dusky to blackish on distal half of 2d and 3d pairs of femora, distal tips of tibiæ and entire tarsi; cornicles and cauda dusky.

Measurements: Body 1.40 mm.; hind tibiæ .50 mm. (.40 to .50 mm.); antennæ .80 mm.; joints as follows: III, .17 mm. (.14 to .18 mm.); IV, .11 mm.; V, .11 mm. (.09 to .13 mm.) VI, .09 mm. + .14 mm. (.11 to .16 mm.); cornicles .07 mm.; cauda .10 mm.

Structural characters: Apterous, secondary sensoria on antennal joint III, 0; on IV, 1 or 2; hind tibiæ very slightly swollen on proximal two-thirds and bearing about 6 flat and very inconspicuous sensoria; all other characters as in apterous viviparous form.

Collections were taken on *Pentstemon* sp. in the vicinity of Fort Collins, Colorado, by L. C. Bragg.

Fundatrix.—One collection, April 23.

Apterous Viviparous Female.—Eleven collections, May 4 to October 20.

Alate Viviparous Female.—Fourteen collections, May 1 to October 20.

Male.—Two collections, October 19 and 20.

Oviparous Female.—Two collections, October 12 to 20.

Types in collection of United States National Museum (Slide No. 41465); paratypes in collection of Colorado Agricultural Experiment Station.

This species differs from *Aphis pentstemonis* Will. (two cotype slides of which were examined), by the possession of sensoria on IV and V, IV and filament being subequal; cauda not so well constricted and more acute, and bearing only 3 hairs on each side. The sensoria are also more tuberculate.

The specimens on the cotype slides mentioned by J. J. Davis* as possessing sensoria on antennal joints IV and V were examined. They are certainly not males, but must belong to a distinct species. They appear to come close to our *Anuraphis pentstemonicola*, but show a distinctly smaller number of sensoria on joint IV.

Aphis phaceliæ, n. sp.

Fundatrix.—(Plate VII, Fig. 9; Plate VIII, Fig. 25). Described from type and 2 paratypes taken on *Phacelia* sp. near Fort Collins, Colorado, April 15, 1919, by L. C. Bragg.

Color: Dorsum pale yellowish-green posteriorly shading anteriorly to pale green or apple-green mottled with darker bluish-green (Killarney green); cauda pale yellowish; legs pale yellowish except tarsi and tips of tibiæ which are black; antennæ pale except joint VI and distal portion of V; eyes and cornicles black.

*"Aphididæ of Nebraska," a Critical Review, p. 18.

Measurements: Body to base of cauda 1.76 mm.; hind tibiae .70 mm.; antennae .70 mm.; joints as follows: III, .30 mm. (.28 to .31 mm.); IV, .11 mm. (.08 to .11 mm.); V, .10 mm. + .12 mm.; cornicles .20 mm.; cauda .12 mm.

Structural characters: Apterous, antenna 5-jointed, without secondary sensoria; hairs short and sparse, as in summer apteræ, which it resembles in all other characters.

Apterous Summer Viviparous Female.—(Plate VIII, Figs. 26 and 28). Described from type and 4 paratypes taken on *Phacelia* sp., at Boulder, Colorado, June 1, 1911, also 2 paratypes taken near Bellvue, Colorado, September 22, 1915, all by L. C. Bragg.

Color of type specimen not observed before mounting in balsam. Paratypes taken September 22, 1915, (Plate VII, Fig. 10) were colored as follows: Dorsum, pale rusty-yellow on head, pale canary-yellow (pinard yellow) on thorax and abdomen, mottled with Killarney green on meso- and metathorax, and first three segments of abdomen; appendages of same color as in fundatrix.

Measurements: Body to base of cauda, 1.20 mm.; hind tibiae .75 mm. (.66 to .75 mm.); antennae 1 mm. (.83 to 1.00 mm.); joints as follows: III, .27 mm. (.20 to .27 mm.); IV, .19 mm. (.14 to .19 mm.); V, .15 mm.; VI, .10 mm. + .19 mm.; cornicles .28 mm. (.20 to .28 mm.); cauda .12 mm.

Structural characters: Secondary sensoria absent, hairs on body, antennae and legs pointed, short, .02 to .03 mm. long, sparse, on cauda curved .07 or .08 mm. long, 3 on each side and one or two located dorsally; cornicles imbricated, cylindrical or somewhat tapering distally, with slight flanges; frontal tubercles lacking; lateral tubercles present on pronotum and abdominal segments 1 and 7; ocular tubercles present.

One example (Plate VIII, Fig. 27) taken in the same collection as the above bore 7 secondary sensoria on joint III of the antennae; the cornicles measured .34 mm., and length of body to cauda 1.80 mm. In all other particulars it agreed with the type and certainly appeared to belong to the same species. The more frequent form, without secondary sensoria could not be considered immature as the shape of antennal joints and cauda were quite clearly that of the mature form.

Alate Viviparous Female.—(Plate VII, Fig. 8; Plate VIII, Figs. 29 and 30). Described from type and 18 paratypes taken on *Phacelia* sp., near Fort Collins, Colorado, by L. C. Bragg.

Color: Head, thorax, lateral spots on abdominal segments, especially a large patch posterior to cornicles, medial dashes on abdominal segments 6, 7 and 8, cornicles, tarsi, and tips of tibiae black; distal one-half to two-thirds of second and third pairs of femora and entire antennae dusky to blackish; abdomen pale apple-green marked with transverse dashes and median line of darker bluish-green, lighter on 6th segment; cauda and remainder of legs pale yellowish; stigmas dusky.

Measurements: Body to base of cauda 1.33 mm.; hind tibiae .80 mm.; antennae 1 mm.; joints as follows: III, .28 mm. (.23 to .28 mm.); IV, .17 mm. (.15 to .19 mm.); V, .14 mm. (.10 to .16 mm.); VI, .09 mm. + .19 mm.; (.19 to .23 mm.); cornicles .19 mm. (.15 to .20 mm.); cauda, .10 mm.

Structural characters: Secondary sensoria on antennal joint III, 8; on IV, 3 (1 to 3); fore wings with mediae twice branched; hind wings with two cross veins; other characters as in apterous viviparae.

Oviparous Female.—(Plate VII, Fig. 11). Described from type and one paratype taken on *Phacelia* sp. near Bellvue, Colordao, September 22, 1915, by L. C. Bragg.

Color: Entire dorsum amber-yellow, mottled with dusky-greenish from prothorax to cornicles, especially outlining eggs within the body; cauda yellowish; antennae pale except joint VI and tip of V, which are dusky; cornicles, tarsi, and tips of tibiae black; hind tibiae brownish along entire length.

Measurements: Body to base of cauda 1.56 mm.; hind tibiae .50 mm.; antennae .83 mm.; joints as follows: III, .17 mm.; IV, .12 mm.; V, .11 mm.; VI, .09 mm. + .16 mm.; cornicles, .13 mm.

Structural characters: Apterous; characters same as in apterous viviparae except hind tibiae which are slightly swollen in proximal half. Sensoria could not be observed in these specimens as they were not sufficiently clear.

Collections were made on *Phacelia* sp. in north central Colorado, by L. C. Bragg.

Apterous Summer Viviparous Female.—One collection, June 1.

Apterous Sexupara.—One collection, September 22.

Alate Viviparous Female.—Four collections, May 16 to June 7.

Oviparous Female.—One collection, September 22.

Alate viviparae were found to be quite numerous, while apterous viviparae were very scarce.

Types in collection of United States National Museum (Slide No. 41466); paratypes in collection of Colorado Agricultural Experiment Station.

Braggia, n. gen *

Characters: Antennae short, about half the length of body; filament of antennal joint VI subequal with base of joint; cornicles conical with wide flanges; dorsum of apterous forms reticulated with white and heavily set with coarse blunt spines or plates; cauda semicircular.

This genus differs from *Anuraphis* Del Guercio by the character of the hairs and the shortness of the antennal filaments. These characters may seem to place it close to *Symydobius* Mordvilko, but the shape of the hairs in the apterous form and the presence of lateral tubercles and much shorter antennae make it seem distinct.

Type: *Braggia echinata*, n. sp.

*The authors take great pleasure in naming this genus for the late Mr. L. C. Bragg, who first collected its type species, and who for several years was a most enthusiastic and efficient co-worker in the study of the aphid fauna of Colorado. In fact, it was through his efforts that a large proportion of the rather extensive collection of *Aphididae* in the Colorado Agricultural Experiment Station was gathered together.

***Braggia echinata*, n. sp**

Apterous Summer Viviparous Female.—(Plate VII, Fig. 13; Plate VIII, Figs. 31, 32 and 33). Described from type and two paratypes taken on *Eriogonum* sp. at Fort Collins, Colorado, June 7, 1916, by L. C. Bragg.

Color: Entire dorsum grayish olive-green marked with a reticulation of raised white waxy secretion and bearing white hairs or spines which are heavy and blunt or slightly enlarged at tip, thus giving a frosted appearance; antennæ and legs pale yellowish except brownish to dusky on distal ends; cornicles greenish-yellow to brown with dark flanges; usually a slight rusty area at base of each cornicle.

Measurements: Body 1.87 mm.; hind tibiæ .55 mm.; antennæ .70 mm.; joints as follows: III, .21 mm.; IV, .12 mm.; V, .11 mm.; VI, .08 mm. + .07 mm.; cornicles .07 mm., but little longer than diameter at base; cauda .07 mm., broader than long.

Structural characters: Secondary sensoria on antennal joints small, round and arranged in a row on posterior side of joint; on III, 4 (2 to 6); IV, 2 (0 to 2); antennal joints coarsely imbricated; hairs on body .03 to .05 mm. long, heavy and blunt; on antennæ very short and sparse or absent; on legs, .02 mm. long and rather sparse; on cauda pointed and slightly curved, 3 lateral and 1 dorsal on each side; cornicles slightly imbricated, not reticulated; conical in shape with distinct neck and wide flange; cauda semicircular with tendency to end in a point, broader than long; frontal tubercles lacking; lateral tubercles present on prothorax and 1st and 7th abdominal segments; ocular tubercles present but small and inconspicuous.

Alate Viviparous Female.—(Plate VII, Fig. 12; Plate VIII, Fig. 34). Described from type and 2 paratypes taken June 9, 1916, also 6 paratypes taken October 12, 1916, all on *Eriogonum* sp. at Fort Collins, Colorado, by L. C. Bragg.

Color: Head and thorax brown to blackish; abdomen yellowish olive-green; cauda concolorous with body, antennæ dusky to blackish except base of joint III, legs pale yellowish with distal half of femora brownish, tarsi and tips of tibiæ black; cornicles yellow-brown; stigmas dusky yellow.

Measurements: Body 1.40 mm.; hind tibiæ .50 mm.; (.47 to .60 mm.); antennæ .75 mm.; joints as follows: III, .25 mm.; IV, .15 mm.; V, .15 mm.; VI, .09 mm. + .07 mm.; cornicles .07 mm.; cauda .05 mm., broader than long.

Structural characters: Secondary sensoria on antennæ round but slightly convex, arranged in irregular row on posterior side of joint, on III, 8 (8 to 12); IV, 3; hairs similar to those on apterous form but so small and sparse on body as not to be noticeable except on lateral portions of abdominal segments 7 and 8; cornicles, cauda and tubercles as in apteræ; fore wings with mediæ twice branched; hind wings with two cross veins.

Oviparous Female.—(Plate VII, Fig. 14; Plate VIII, Figs. 36 and 37). Described from type and 8 paratypes taken October 6 and 7, 1916, also 9 paratypes taken October 17, 1916, by L. C. Bragg.

Color: Entire dorsum dusky olive-brown tinged with pinkish or rusty laterally and posteriorly covered as in apterous viviparæ with white reticulations and heavy, blunt, white spines; antennæ and legs darker than in apterous viviparous form, with entire hind tibiæ blackish. Immature forms resemble the viviparæ in color.

Measurements: Body, 1.62 mm.; hind tibiæ .50 mm.; antennæ .60 mm.; joints as follows: III, .17 mm.; IV, .12 mm.; V, .12 mm.; VI, .08 mm. + .07 mm.; cornicles .05 mm.; cauda, .05 mm.

Structural characters: Apterous; secondary sensoria on antennæ as in apterous viviparæ or tending to be slightly fewer; hind tibiæ swollen for almost entire length and bearing rather large, flat sensoria scattered over four-fifths of length; other characters as in apterous viviparæ.

Male.—(Plate VII, Fig. 15; Plate VIII, Fig. 35). Described from type and 6 paratypes on slides with oviparæ described above.

Color: Pupæ with pink abdomen, greenish thorax and black wing pads. Adults with head and thorax dark brown to black; abdomen pinkish to dark rusty-brown; antennæ dusky to black, legs sordid with the tips black.

Measurements: Body, 1 mm. (1 to 1.40 mm.); hind tibiæ .55 mm.; antennæ .80 mm.; joints as follows: III, .24 mm.; IV, .16 mm.; V, .15 mm.; VI, .10 mm. + .09 mm.; cornicles .04 mm.; cauda, .03 mm.

Structural characters: Alate, secondary sensoria on antennæ as follows: on III, 30; IV, 15; V, 13; VI, 0 to 3; all other characters as in alate viviparæ.

Collections were taken on *Eriogonum* sp. at Fort Collins, Colorado, by L. C. Bragg as follows:

Apterous Viviparous Female.—Five collections, June 7 to October 7.

Alate Viviparous Female.—Five collections, July 8 to October 17.

Male.—Four collections, October 6 to 17.

Oviparous Female.—Six collections, October 6 to 17.

Types in collection of United States National Museum (Slide No. 41468); paratypes in collection of Colorado Agricultural Experiment Station.

Lachnus medispinosus, nov. nom. is here proposed for *Lachnus similis* Gill. and Pal. (published in 1924 in Ann. Ent. Soc. of Am. XVII: 1, 23), the original name having been preoccupied by Van der Goot in 1917.

Myzus essigi, nov. nom. is here proposed for *Myzus aquilegia* Essig (pub. 1917. Univ. of Calif. Pub. Ent. I, 314). Essig's name used by Theobald in 1913 (Jo. Ec. Biol. VIII, 92, 24).

EXPLANATION OF PLATES.

PLATE I.

- Plocamaphis braggi*, n. sp. 1, apterous summer viviparous ♀; 2, alate summer viviparous ♀; 3, ♂; 4, oviparous ♀.
Anuraphis ornata, n. sp. 5, alate summer viviparous ♀; 6, apterous summer viviparous ♀; 7, young.
Anuraphis chrysothamnicola, n. sp. 8, oviparous ♀; 9, ♂; 10, apterous summer viviparous ♀; 11, young; 12, alate summer viviparous ♀.

PLATE II.

- Plocamaphis braggi*, n. sp. 1, antenna of apterous summer viviparous ♀; 2, cauda of same; 3, antenna of alate summer viviparous ♀; 4, cornicle of same; 5, antenna of oviparous ♀; 6, cornicle, and 7, hind tibia of same; 8, antenna of ♂.
Anuraphis chrysothamnicola, n. sp. 9, antenna of apterous summer viviparous ♀; 10, antenna of alate summer viviparous ♀; 11, cauda of apterous summer viviparous ♀; 12, cauda of alate summer viviparous ♀; 13, cornicle of apterous viviparous ♀; 14, cornicle of alate viviparous ♀; 15, antenna of oviparous ♀; 16, cornicle of same; 17, antenna of male; 18, cornicle of same; 19, hind tibia of oviparous ♀.
Anuraphis ornata, n. sp. 20, antenna of alate viviparous ♀; 21, cornicle, and 22, cauda of same; 23, antenna of apterous summer viviparous ♀; 24, cauda of same; 25, antenna of male; 26, antenna of oviparous ♀; 27, cornicle, and 28, hind tibia of same.

PLATE III.

- Anuraphis flocculosa*, n. sp. 1, apterous summer viviparous ♀; 2, alate viviparous ♀.
Anuraphis senecioradialis, n. sp. 3, apterous summer viviparous ♀; 4, alate viviparous ♀.
Anuraphis debilicornis, n. sp. 5, oviparous ♀; 6, alate viviparous ♀.
Siphonotrophia gravis, Knowl. 7, fundatrix; 8, young (1st instar); 9, alate viviparous ♀; 10, oviparous ♀ (side view on leaves of host); 11, oviparous ♀ (dorsal view); 12, egg; 13, apterous ♂; 14, alate ♂.

PLATE IV.

- Anuraphis flocculosa*, n. sp. 1, antenna of apterous summer viviparous ♀; 2, antenna, 3, cauda, and 4, cornicle, of alate viviparous ♀; 5, cauda, and 6, cornicle of apterous summer viviparous ♀; 7, antenna of ♂; 8, antenna, and 9, hind tibia of oviparous ♀.
Anuraphis senecioradialis, n. sp. 10, antenna of alate viviparous ♀; 11, antenna, 12, cornicle, and 13, cauda, of apterous summer viviparous ♀; 14, cauda of alate viviparous ♀; 15, antenna of ♂; 16, antenna, and 17, hind tibia of oviparous ♀.
Anuraphis debilicornis, n. sp. 18, antenna, and 19, cornicle of alate viviparous ♀; 20, antenna, and 21, cornicle of apterous summer viviparous ♀; 22, antenna, and 23, cornicle of ♂; 24, antenna, 25, cornicle, and 26, hind tibia of oviparous ♀; 27, cauda of alate viviparous ♀.
Siphonotrophia gravis, Knowl. 28, antenna of fundatrix; 29, antenna, 30, cornicle, and 31, cauda, of alate viviparous ♀; 32, antenna of apterous summer viviparous ♀; 33, antenna, and 34, hind tibia of oviparous ♀; 35, antenna of alate ♂.

PLATE V.

- Anuraphis laciniaria*, n. sp. 1, alate viviparous ♀; 2, apterous summer viviparous ♀.
Aphis fraseræ, n. sp. 3, alate viviparous ♀; 4, apterous summer viviparous ♀.
Aphis cercocarpi, n. sp. 5, apterous summer viviparous ♀; 6, alate viviparous ♀.
Aphis n. sp. 7, apterous viviparous ♀; 8, alate viviparous ♀.
Aphis ribiæ, n. sp. 9, fundatrix; 10, alate viviparous ♀; 11, oviparous ♀; 12, freshly laid egg; 12a, egg a few days after being laid; 13, ♂
Aphis asterensis, n. sp. 14, apterous summer viviparous ♀; 15, alate viviparous ♀.

PLATE VI.

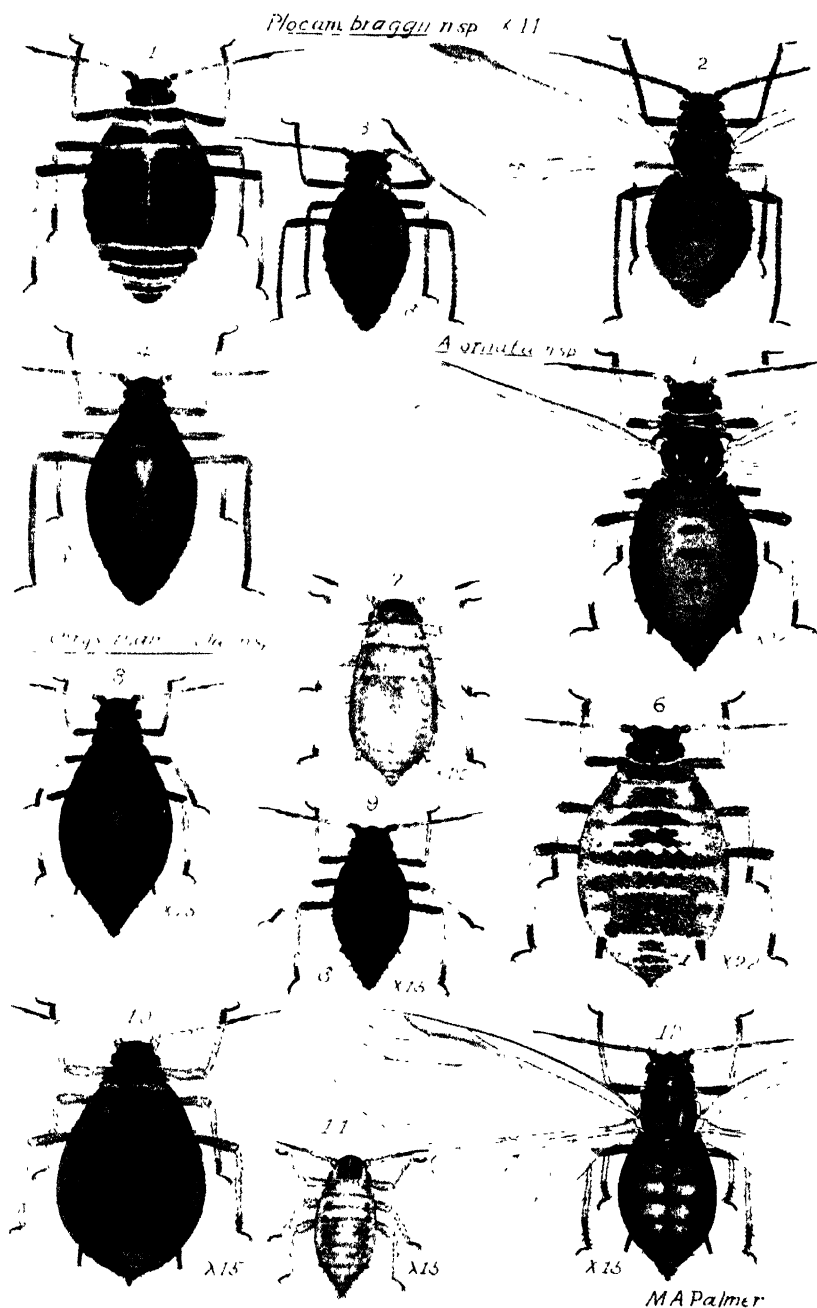
- Anuraphis laciniaria*, n. sp. 1, antenna, 1a, cornicle of apterous summer viviparous ♀; 2, antenna, 3, cauda, of alate viviparous ♀; 4, hind tibia of oviparous ♀.
Aphis fraseræ, n. sp. 5, antenna of typical form, 5a, antenna of less usual form, 6, cornicle, and 7, cauda of apterous summer viviparous ♀; 8, antenna, and 9, cornicle of alate viviparous ♀.
Aphis cercocarpi, n. sp. 10, antenna, and 11, cauda of apterous summer viviparous ♀; 12, antenna, and 13, cornicle of alate viviparous ♀; 14, cornicle of apterous summer viviparous ♀.
Aphis lupini, n. sp. 15, antenna of apterous summer viviparous ♀; 16, cauda, 17, antenna, and 18, cornicle of alate viviparous ♀; 19, cornicle of apterous summer viviparous ♀.
Aphis ribiæ, n. sp. 20, antenna of fundatrix; 21, antenna, and 22, cornicle of apterous summer viviparous ♀; 23, antenna, 24, cauda, and 25, cornicle of alate viviparous ♀; 26, antenna and 27, cornicle of ♂; 28, antenna, 29, hind tibia, and 30 and 30a, cauda of oviparous ♀.

PLATE VII.

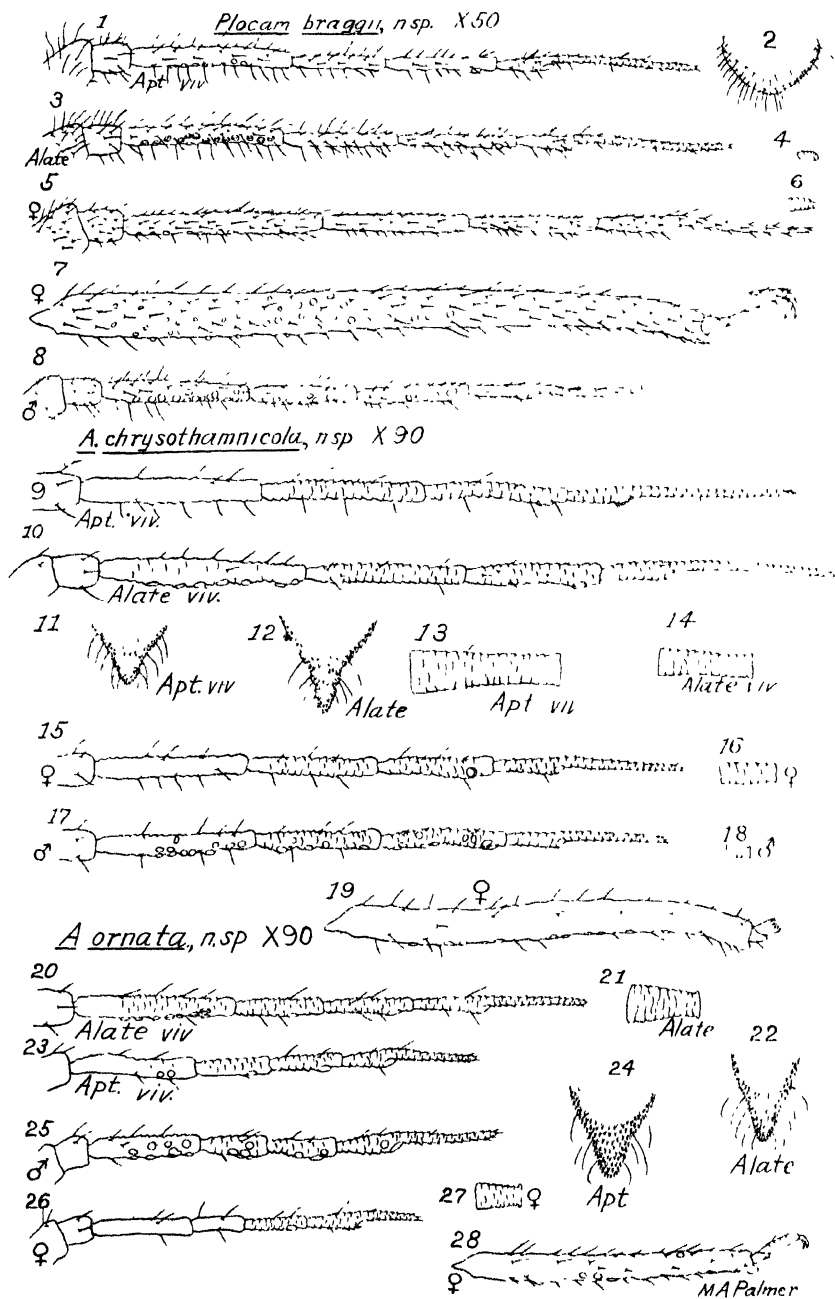
- Aphis pentstemonicola*, n. sp. 1, fundatrix; 2, young born of fundatrix; 3, alate viviparous ♀; 4, apterous summer viviparous ♀; 5, young born of summer viviparous ♀; 6, oviparous ♀; 7, ♂.
Aphis phaceliæ, n. sp. 8, alate viviparous ♀; 9, fundatrix, 10, late apterous viviparous ♀; 11, oviparous ♀.
Braggia echinata, n. sp. 12, alate viviparous ♀; 13, apterous summer viviparous ♀; 14, oviparous ♀; 15, ♂.

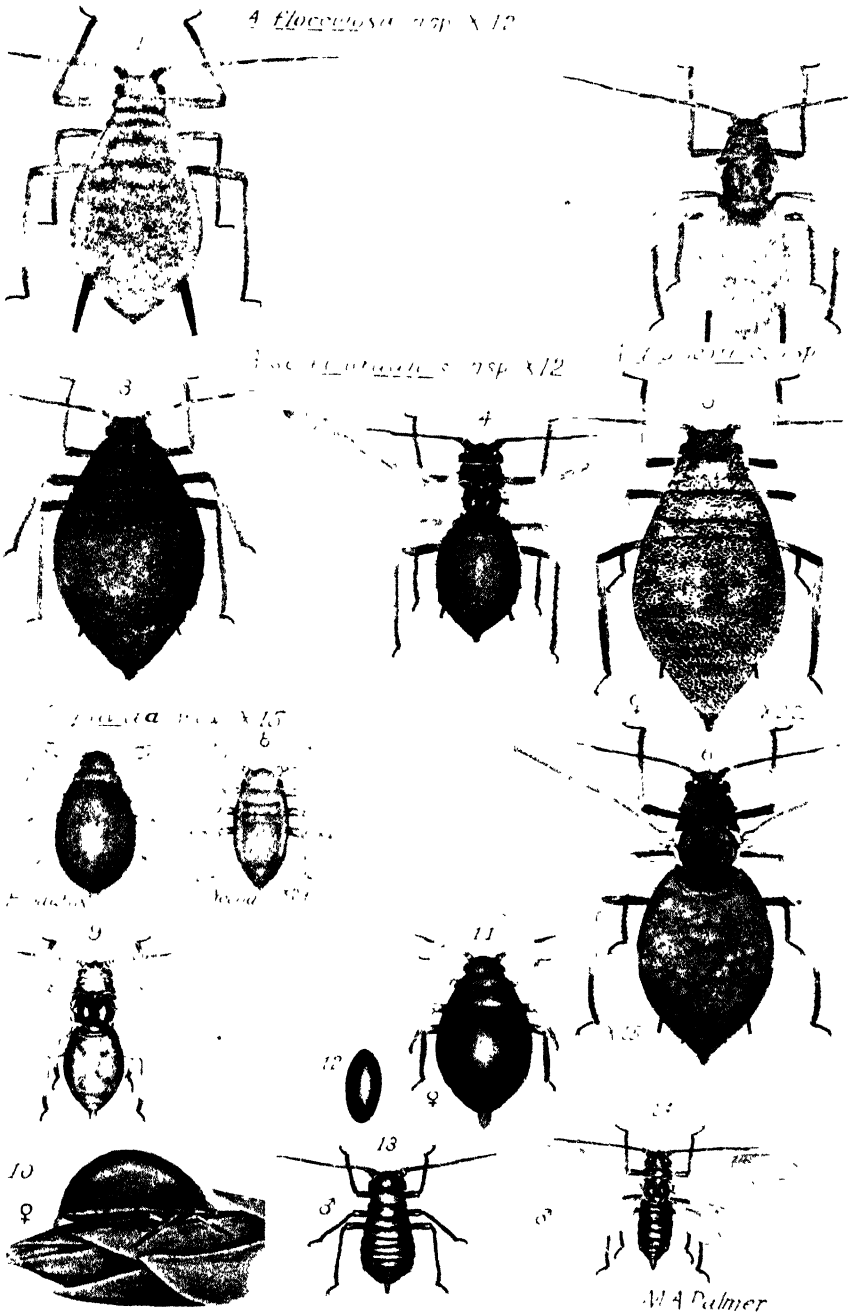
PLATE VIII.

- Aphis asterensis*, n. sp. 1, antenna of apterous summer viviparous ♀; 2, cornicle, and 3, cauda of same; 4, alate viviparous ♀; 5, cornicle, and 6, cauda of same; 7, antenna of ♂; 8, antenna of oviparous ♀; 9, cornicle, and 10, hind tibia of same.
Aphis pentstemonicola, n. sp. 11, antenna of fundatrix; 12, cornicle of same; 13, antenna of apterous summer viviparous ♀; 14, cornicle of same; 15, antenna of alate viviparous ♀; 16, cornicle of same; 17, cauda of apterous summer viviparous ♀; 18, cauda of alate viviparous ♀; 19, antenna of ♂; 20, cornicle, and 21, cauda of same; 22, antenna of oviparous ♀; 23, cornicle, and 24, hind tibia of same.
Aphis phaceliæ, n. sp. 25, antenna of fundatrix; 26, antenna of typical, 27, antenna of atypical, and 28, cauda, of apterous summer viviparous ♀; 29, antenna, and 30, cornicle of alate viviparous ♀.
Braggia echinata, n. sp. 31, antenna, 32, cornicle, and 33, cauda of apterous summer viviparous ♀; 34, alate viviparous ♀; 35, antenna of ♂; 36, antenna, and 37, hind tibia of oviparous ♀.

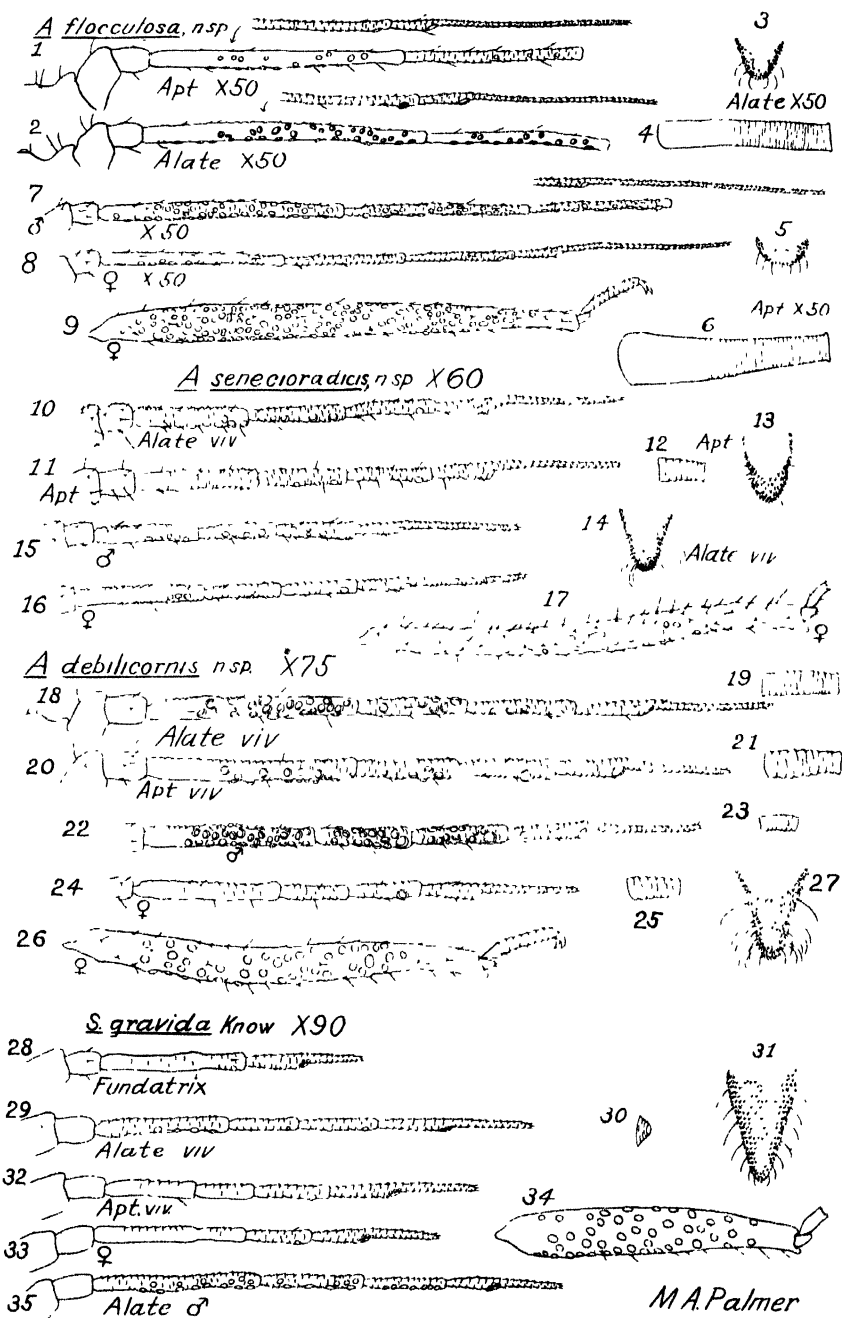


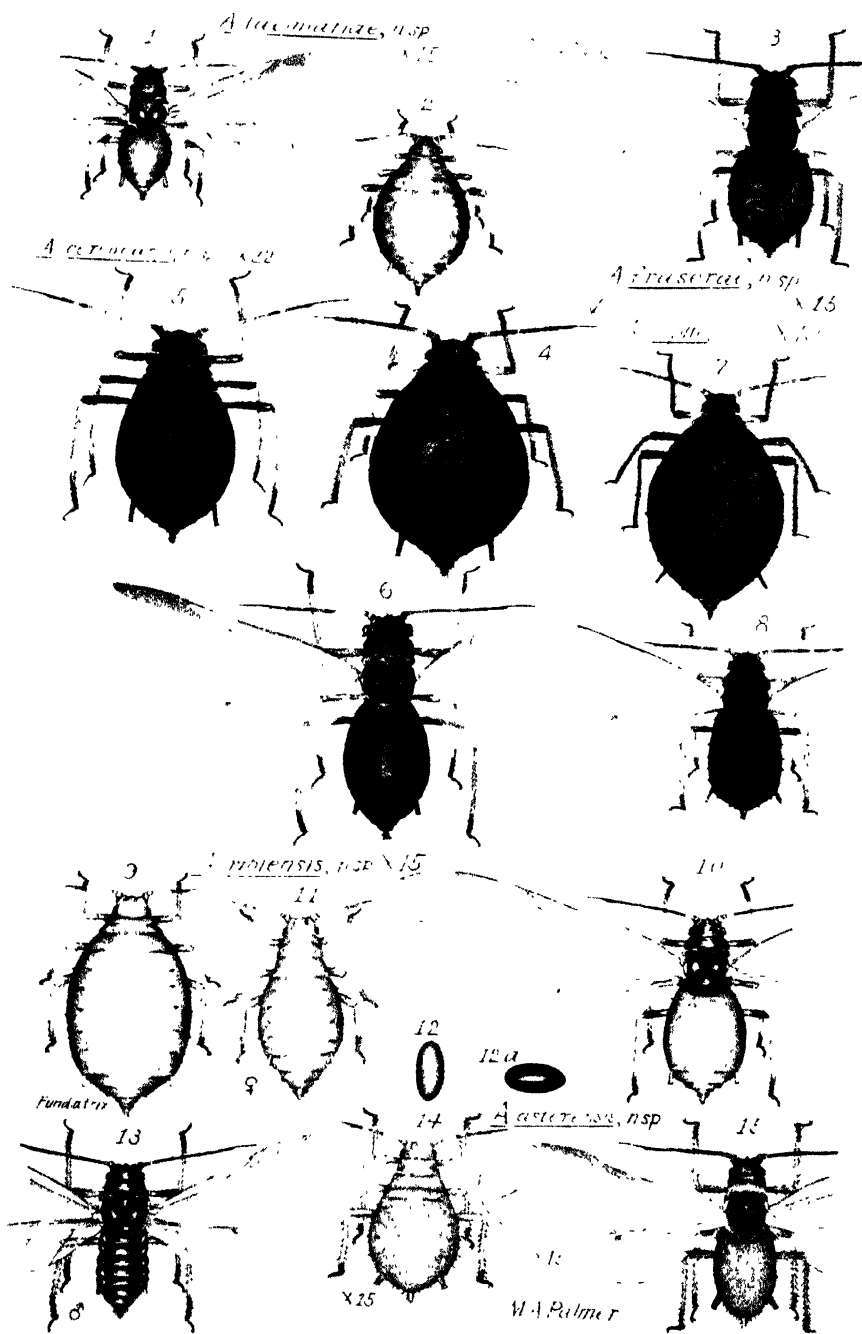
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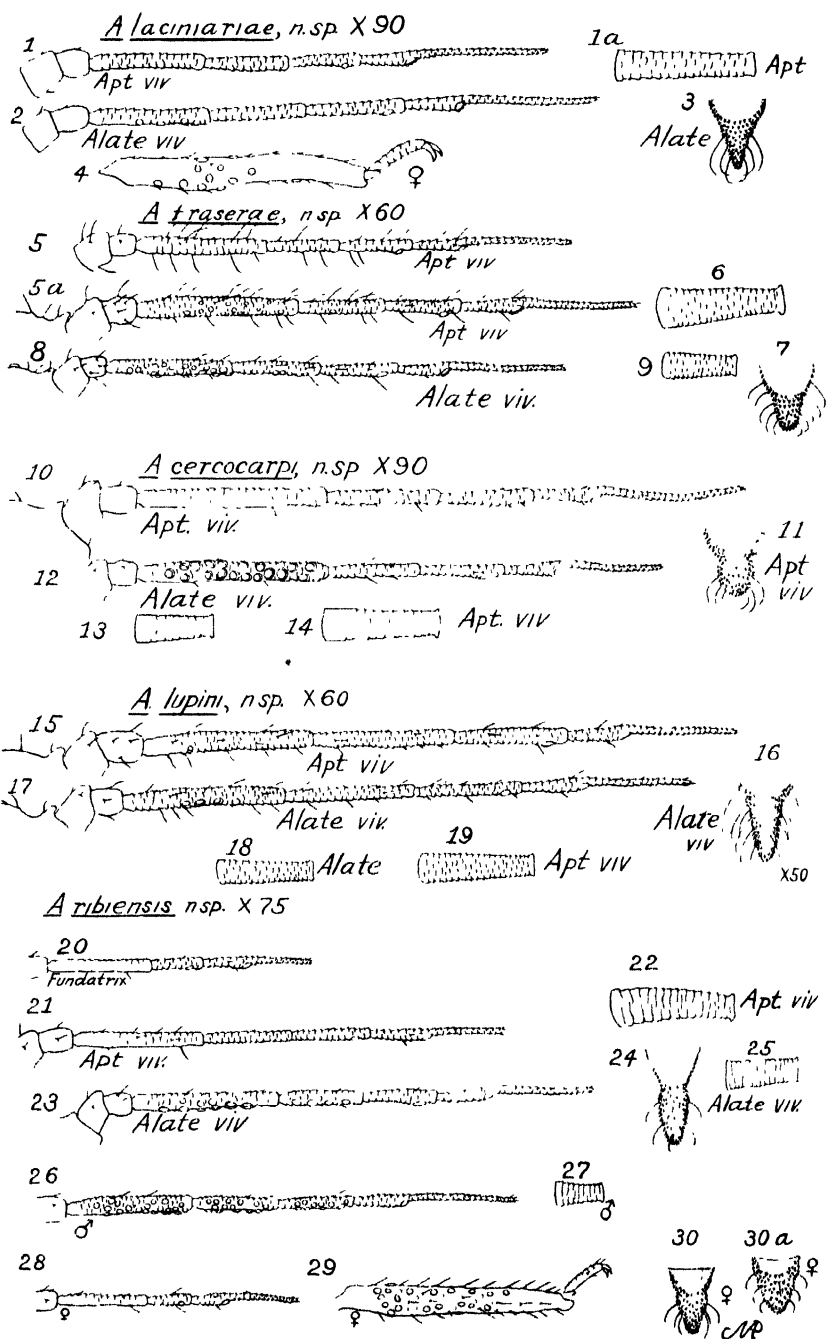




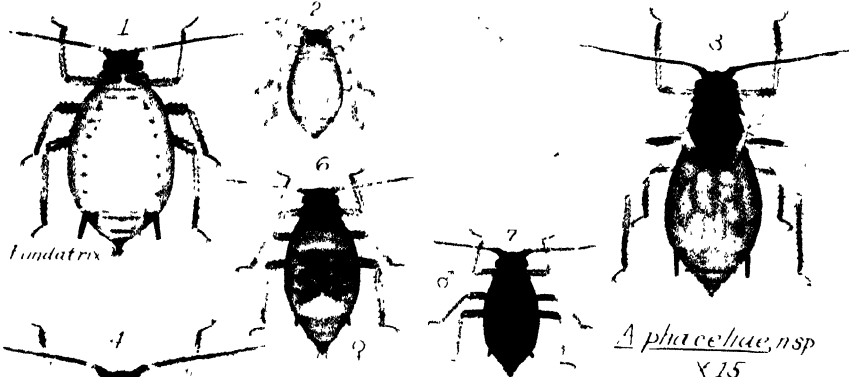
W A Palmer







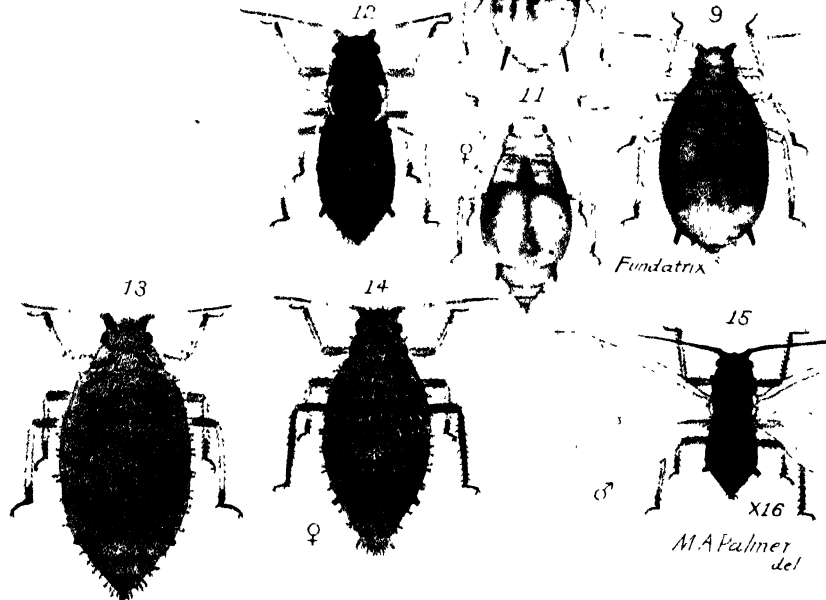
Apentstemonicola, n. sp. X 75

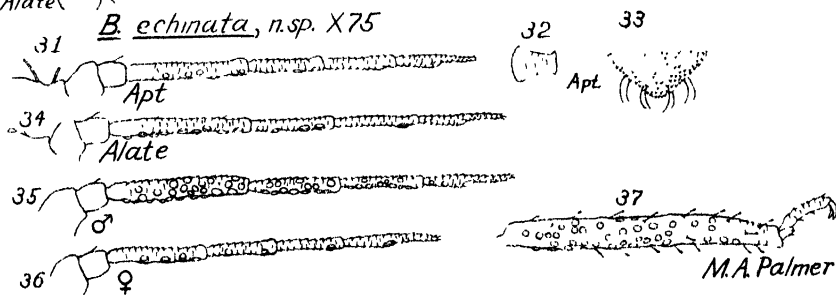
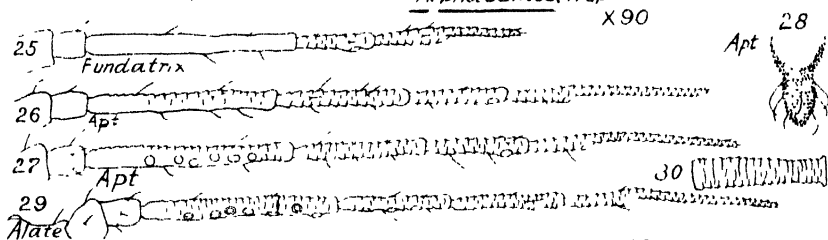
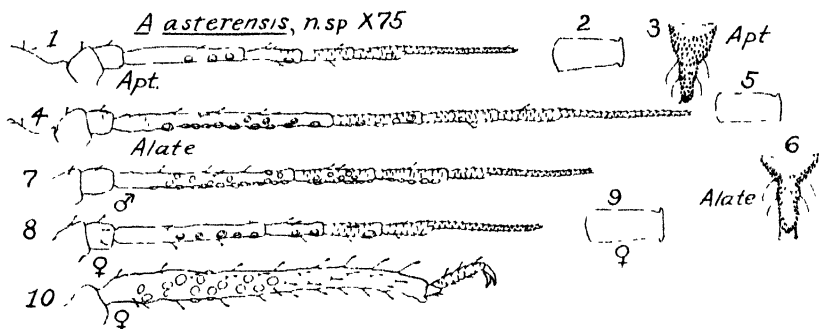


Aphaece/ae, n. sp. X 15



B. c. lunata, n. sp. X 20





SOME NEOTROPICAL SCALE INSECTS ASSOCIATED WITH ANTS.*

(Hemiptera-Coccidæ).

By HAROLD MORRISON,
Bureau of Entomology, Washington, D. C.

Nearly all of the species of Coccidæ discussed in the following paper were received for study through Dr. W. M. Wheeler of Bussey Institution, Harvard University, and most of the material considered was collected by him in person in the Canal Zone and a few adjacent parts of the Republic of Panama. Others of the specimens discussed here were collected by Mr. James Zetek, of the Bureau of Entomology, located in the Canal Zone, who has, in the course of his work for the Bureau, collected a large series of specimens of scale insects, including many interesting forms in addition to those reported on here. The remaining specimens came from Vera Cruz, Mexico, Dutch and British Guiana and Trinidad. Studies on these specimens have naturally been materially aided by the availability of the large National Collection of Coccidæ, built up through many years of work on the part of the Bureau of Entomology of the United States Department of Agriculture, and the types of the new species described have been deposited in that collection.

The drawings illustrating the structural characters of the species described as new have been prepared by Miss Leola J. Kruger. The names of the ants involved, where given, have in each case been furnished by Dr. Wheeler.

Only two of the larger groups of the Coccidæ are represented in this material. They include the subfamily Coccinæ and a portion of the subfamily Dactylopinae of the Fernald Catalogue for the first time formally restricted and elevated in rank as the subfamily Pseudococcinæ.

* This paper was completed in March, 1924, and has not been revised prior to publication.

Subfamily PSEUDOCOCCINÆ.

The name *Pseudococcinæ* has been used previously by Brain (1, p. 79)†, and perhaps others, but apparently only as a substitute for the older name *Dactylopiinæ*. In its usage in this paper it is restricted to a group of genera, comprising a part of the old subfamily *Dactylopiinæ*, which are known to have at least one pair of dorsal ostioles, which, with very rare exceptions, have a small triangular and usually trilocular pore as the characteristic type and which have other, although often less tangible, morphological and habit characteristics. It is the writer's impression that this group has been recognized and definitely pointed out previously only by Professor Ferris (3, p. 30; 4, p. 60) who has definitely fixed its status by indicating most of the genera that can be properly included in it. The writer has for some time believed that this group of genera was entitled to subfamily standing in any system of classification which considers the scale insects as a family. Although reluctant to be the first to make use of the name in such a restricted sense in this rather incidental fashion, he has decided to employ it as indicated.

Genus *Pseudococcus* Westwood.*Pseudococcus brevipes* Cockerell.

Cockerell (4, p. 308) has called attention to the fact that Bouché's use of the name *bromeliæ* in connection with the genus *Coccus*, was antedated many years by Kerner's publication of the same combination. An examination of Bouché's 1833 publication (2, p. 49), which the writer has finally been able to obtain, shows that the name "*Coccus bromeliæ*" was here used by Bouché and so verifies Cockerell's statement to the effect that this name is a homonym of *Coccus bromeliæ* Kerner, 1778.

It would seem, in consequence, that there is no alternative to accepting the next name which has been applied to the species, this apparently being *brevipes* Cockerell, 1893, which species, as the writer (9, p. 133) has stated, is identical with that which has in recent years been accepted as *bromeliæ* Bouché by all coccidologists. The erroneous citation of

† Numbers in parentheses refer to literature cited.

Bouché's original reference to this species as "*Lecanium bromeliae*" in the Fernald Catalogue (7, p. 98) obscured the fact that a homonym had been established and that a change of name would be necessary.

With regard to the remainder of Professor Cockerell's conclusions on this subject, and dealing with the true identity of the *Coccus bromeliae* of Bouché, the evidence of identity with the species now known as *Saissetia hemisphaerica* (Targ.) does not appear to the writer to be so conclusive as Professor Cockerell believes. A comparison of the original of Bouché's 1834 description (3, p. 20) of *Coccus bromeliae* with what purports to be the same description translated into French, as given by Signoret in 1876, shows that the use of quotation marks has been rather abused by the translator. Thus, among other omissions and changes in the description of the female the following entire sentence, having an important bearing on the identity of this species, is omitted: "on the back of the animal are on each side two elevated cross bars—the boundaries between head, thorax and abdomen" (literal translation). This, in itself, certainly suggests *Saissetia oleae* rather than *S. hemisphaerica*, but the body color as given by Bouché (pale brown) suggests *hemisphaerica* or possibly early adult *oleae*.

The species *Lecanium bromeliae* (Bouché), so far as the writer has been able to discover, dates from Burmeister's Handbuch der Entomologie, 1835, and was intended to be identical with Bouché's *Coccus bromeliae*, and should be so considered.

The collections reported on herewith contain a number of lots of specimens which have been placed as *Pseudococcus brevipes* (Ckll.). In connection with the identification of these Panamanian mealybugs, the material from British Guiana previously published (9) has been reexamined, with the result that one lot, as noted in connection with the discussion of the new species immediately following, has been eliminated from those identified from British Guiana as *bromeliae*. This elimination removes the only specimens from British Guiana having 6-segmented antennae and leaves all the specimens now included under *bromeliae* with a range of antennal segmentation of from seven to eight instead of from six to eight.

The species of *brevipes* is represented by the following lots of material, collected by Dr. Wheeler in the Canal Zone: In

Cecropia, Salud, Rio Auga, March 6, with *Azteca* sp. (No. 120); in *Cordia alliodora* Rutz and Pavon, Red Tank, March 10, with *Azteca longiceps* Emery (No. 141); in *Triplaris cumingiana*, Las Cascadas, March 14, with *Azteca longiceps* (No. 167), with *Pseudomyrma christopherseni* Ford (No. 168), with *Azteca* sp. (No. 171); and in the same host, Miraflores, March 17, with *Cremalogaster* sp. (No. 178, 181).

***Pseudococcus maritimus* (Ehrh.).**

The collection contains a single specimen of a mealybug which it has not been possible to differentiate from presumably typical California specimens of this species. This adds another record to the constantly widening known distribution of this insect. The specimen was collected by Dr. Wheeler in *Cordia alliodora*, at Red Tank, Canal Zone, April 10, unattended by ants (No. 333).

***Pseudococcus probrevipes*, new species.**

So far as known definitely, occurring only within swellings (myrmecodomatia) of the host twigs, attended by ants.

Adult female.—Described from alcoholic material only, so nothing regarding external appearance and secretion can be stated; very similar to *brevipes*, (*bromeliae* of authors), differing principally in comparative characters; antennae normally 7-segmented, rarely 6-segmented, in contrast to the eight segments normally, but by no means always, found in *brevipes*; ventral chitinous thickening of anal lobes relatively quite elongate and narrow as compared with the normally irregularly quadrate thickening of *brevipes*, this character varying quite considerably in both species; with a loose band or cluster of setae of only moderate length (about 14μ) immediately anterior to the anal ring dorsally, in contrast to the presence of a cluster of long slender setae (about 35μ) in *brevipes*, this character the most tangible differentiating one found thus far; antennal segments showing the following range of lengths, the measurements given in microns: I, 43-53; II, 36-43; III, 36-40; IV, 22-43; V, 18-28; VI, 29-35; VII, 66-80; legs stout, hind tibiae and femora with numerous small pores; number of spines in cerarii varying considerably, but about as follows: I (anterior), 3-4; II, 2-4; III, 2-3; IV, 2; V, 2; VI, 3; VII, 2-3; VIII, 1-3; IX, 2-3; X, 2; XI, 2-3; XII, 2; XIII, 2-4; XIV, 2-3; XV, 2-4; XVI, 3; XVII, 2; one lot of material (Wheeler No. 62) with the spines averaging distinctly more numerous, as follows from anterior to posterior: 4-6, 3-6, 2-3, 2-3, 3-4, 2-3, 2-4, 2-3, 2-3, 2-5, 2-5, 2-3, 2-6, 2-5, 3-7, 3-6, 2; accessory setae of cerarii tending to stoutness, some almost spine-like in contrast to those of *brevipes*, but this apparently variable.

This species has been characterized from one or more specimens from the following lots of material obtained by Dr. Wheeler in the Canal Zone: In *Cordia alliodora*, Frijoles, March 28, with *Azteca longiceps* (No. 232) (holotype and paratypes); Ancon, March 5, with *Pseudomyrma sericea* (No. 110); Red Tank, March 10, (No. 150); Quebrada de Ore, March 13, with *Crematogaster* sp. (No. 159); Las Cascadas, March 14, with

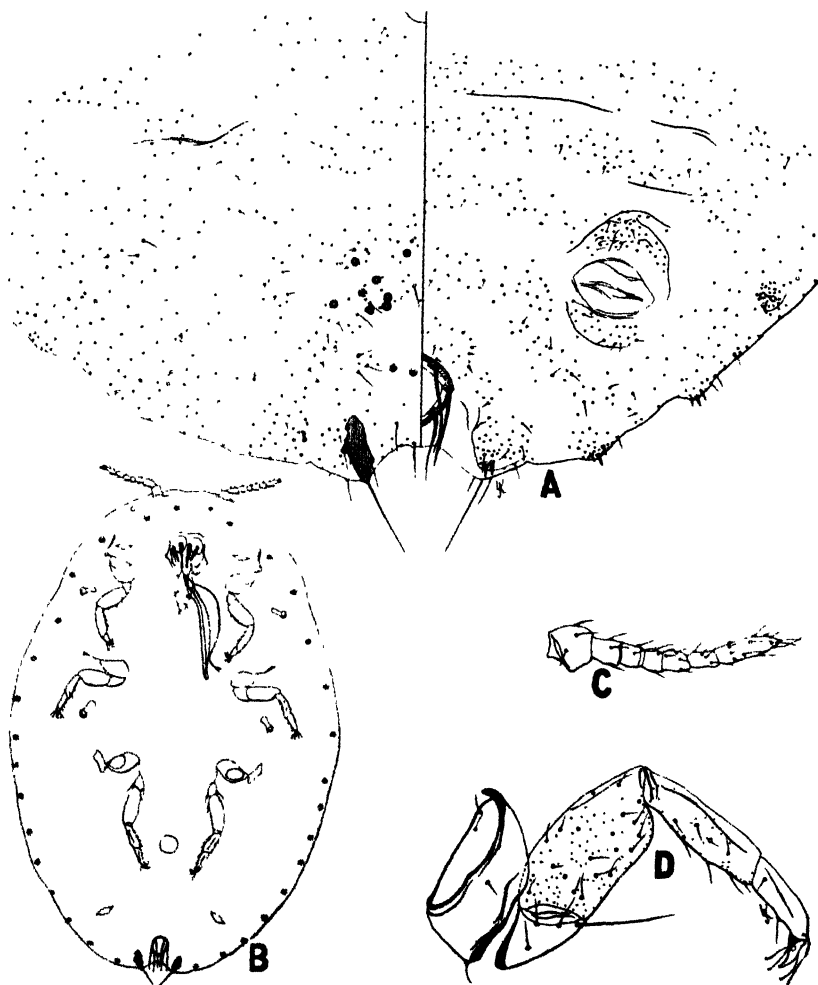


FIG. 1. *Pseudococcus probrevipes*, new species, all adult female.

A, apex of abdomen, showing pores, setae, cerarii, anal ring, thickening, ostiole, dorsal to right, $\times 120$; B, outline of body, optical section, showing parts, $\times 30$; C, antenna, $\times 120$; D, posterior leg, showing pores, $\times 120$.

Azteca sp. (No. 166); Barro Colorado Id., March 20, with *Azteca longiceps* (No. 201 and 207); in *Triplaris cumingiana*, Ft. Clayton, February 28, with *Azteca* sp. (No. 62); Balboa, C. Z., March 26, with *Azteca* sp. (No. 225) and *Pseudomyrma christophersenii* (No. 226) (all paratypes). This species was also collected by Dr. Wheeler in several localities as indicated by these records: In *Cordia alliodora*, Barro Colorado Id, June 27, (No. 585), and July 21, (No. 730); Agua Clara Reservoir, Ft. Davis, C. Z., July 5, (No. 607); Gamboa, July 9, (No. 642); Corozal, July 12, (No. 666); Ancon, August 6, (No. 847). After re-examining the specimens recently reported on from the British Guiana (9, p. 133), the writer is of the opinion that one lot of these, that collected in *Cordia* with *Allomerus 8-articulatus* at Kartabo, July-August 1920, should be associated with the species characterized above rather than with *brevipes*.

***Pseudococcus rotundus* Morrison.**

A single lot of material from the general type locality has been examined. These specimens, which appear to be entirely typical of the species, were collected in *Cecropia peltata* at Blairmont, British Guiana, with *Azteca alfari* var., on February 19, 1924, by H. E. Box.

***Pseudococcus texensis* Tinsley.**

A comparison with the types shows that material collected in thorns of *Acacia veracruzensis* at Vera Cruz, Mexico, in 1924 by Dr. A. Dampf, is this species, which was originally described from an *Acacia*. Dr. Wheeler states that two species of ants, *Crematogaster corvina* (Mayr) and *C. (Orthocrema) atra* Mayr, inhabited the interior of the *Acacia* thorns.

Genus *Farinococcus* Morrison.

***Farinococcus multispinosus* Morrison.**

This species is represented by a few specimens collected in hollow branches of *Triplaris surinamensis* at Blairmont, British Guiana, with *Pseudomyrma triplaridis* Forel. sub sp. *boxi*, n. sub sp. Wheeler, on February 14, 1924, by H. E. Box. These specimens are dry and enough of the waxy secretion remains attached to them to indicate that they are probably rather heavily coated in life and have a heavy, continuous marginal band of white waxy secretion.

Subfamily COCCINÆ.

Genus *Coccus* Linnaeus.*Coccus elongatus* (Sign.).

A single specimen of this species, collected by Dr. Wheeler in spines of *Acacia penonomensis* Safford, Pueblo Nuevo, Panama, with *Pseudomyrma gracilis* (No. 271) is included in the collection.

Coccus hesperidum L.

Specimens, apparently this species, although considerably smaller than typical individuals and abnormal in shape, were obtained by Dr. Wheeler on leaves of *Cordia alliodora* at Ancon, Canal Zone, attended by *Azteca* sp. April 9, 1923 (No. 311).

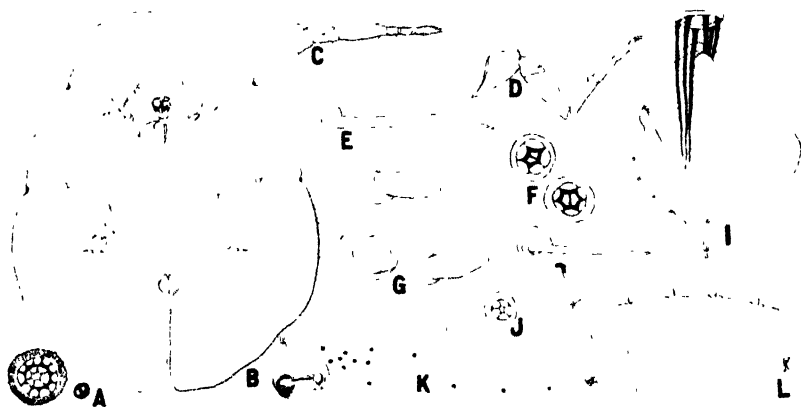


FIG. 2. *Mesolecanium inquilinum*, new species, all adult female.

A, dorsal pores, $\times 1000$; B, body outline, optical section, showing parts and few dorsal pores, $\times 18$; C, antenna, $\times 80$; D, leg, $\times 80$; E, marginal spine, $\times 1000$; F, ventral abdominal disk pores, $\times 1000$; G, spiracular spines, $\times 1000$; H, dorsal seta, $\times 1000$; I, anal plates, ventral to left, $\times 153$; J, spiracular disk pore, $\times 1000$; K, spiracles to margin, $\times 80$; L, margin showing derm areolations, $\times 40$.

Genus *Mesolecanium* Cockerell.

The described Central American species of this genus, including those from Mexico and that considered below, appear to form a compact group of species whose separation is difficult, if not impossible, on the basis of the material at present available for study. The status of the new species described herewith is therefore somewhat uncertain.

Mesolecanium inquilinum new species.

Living on the host bark within ant cartons.

Adult female.—Very closely resembling the genotype *M. nocturnum* (Ckll. and Parr.), apparently differing only in having noticeably fewer dorsal, compound, circular, disk-like pores anterior to the anal ring, in having the lateral spiracular spines shorter and stouter than in the enotype and in having the sub-marginal areolations, in general, smaller and more irregular in shape. Various details of the structure are shown in Figure 2.

This species has been described from three mounted specimens collected on an unknown host in tents of *Azteca*, Las Cascadus Cacao Plantation, Canal Zone, March 14, 1923, by W. M. Wheeler and J. Zetek (Z-1887).

Genus Neolecanium Parrott.

The two species described below and assigned to this genus cannot be considered as characteristic or typical and will probably be assigned to a hitherto unrecognized genus when the subfamily is given a critical revision.

Neolecanium craspeditæ, new species.

Occurring on the limbs and branches of the hosts, normally within ant cartons.

Adult female.—Maximum length about 2.5 mm., width about 2 mm., height about 1.5 mm., hemispherical, but most specimens smaller and very much flatter than this, the early adults having the disk completely depressed and less prominent than the heavily chitinized, strongly protruding marginal rim; color bright reddish brown, the centrally located anal plates a little more reddish, the marginal rims much darker, sometimes piceous, early adult female covered with a thin film of whitish, easily detached wax, the surface of this sometimes faintly nodulose but without traces of this wax in the fully developed female; surface of body of early adult faintly shining, that of mature adult highly polished; maximum length and width of body as mounted on slide slightly more than dimensions given above; derm clearing completely or, at most, in only a narrow band between disk and rim, depending on state of development; marginal rim and anal plates always more heavily chitinized than the remainder of body; derm with a rather conspicuous cluster of scattered disks on each side of the anal plates, and with numerous, but isolated, small, short tubular ducts distributed rather uniformly over most of the dorsal surface; antennæ somewhat reduced, normally 6-segmented, dimensions somewhat variable, measurements of one in microns as follows: I, about 15; II, 18; III, 45; IV, 10;

V, 9; VI, 18; legs likewise somewhat reduced, appear as shown in figure, trochanter obscured, tibia and tarsus fused, both pairs of digitules distinctly developed; spiracles not unusual, set well in from the body margin, in general resembling those of *Coccus*, joined to margin by a

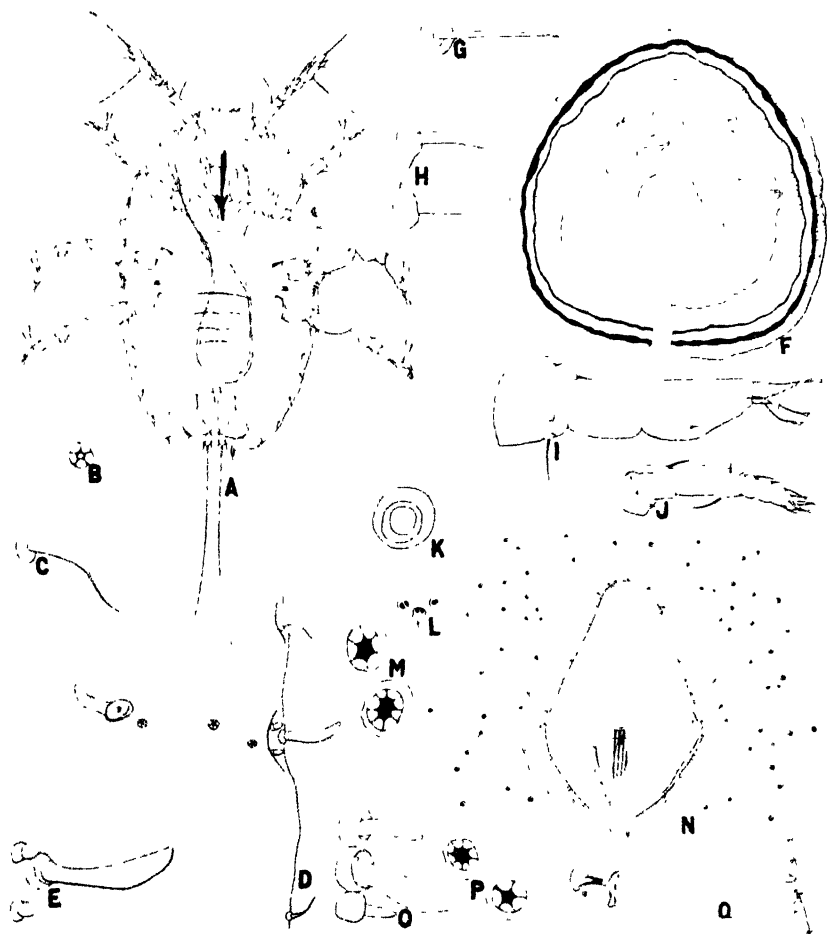


FIG. 3. *Neolecanium craspedota*, new species.

A, larva, outline from below, $\times 153$; B, same, spiracular quinquelocular disk pore, $\times 1000$; C, same, marginal seta, $\times 1000$; D, same, spiracular region at margin, $\times 433$; E, same, spiracular spines, $\times 1000$; F, adult female, outline, optical section, of early adult, showing location of parts and partial chitinzation, $\times 20$; G, same, dorsal seta, $\times 1000$; H, same, marginal seta, $\times 1000$; I, same, leg, $\times 353$; J, same, antenna, $\times 153$; K, same, dorsal pore near anal plate, $\times 1000$; L, same, minute bilocular dorsal pores, $\times 1000$; M, same, ventral disk pores from anal plate region, $\times 1000$; N, same, anal plates, ventral to left, $\times 80$; O, same, spiracular spines, $\times 1000$; P, same, spiracular quinquelocular disk pores, $\times 1000$; Q, same, ventral region between spiracles and margin, $\times 80$.

more or less distinct groove or depression and a row of scattered disk pores; marginal spines straight or somewhat curved, slender, bluntly pointed at apices, set in stout basal collar, average length about 10μ , spaced somewhat irregularly, but mostly three or more times the spine length apart; also with a submarginal row of more slender setae; spiracular spines grouped in threes, all small and fairly stout, the median about 10μ long, the laterals about 6μ long, but all varying somewhat; dorsal surface with a few small slender setae about $7-8\mu$ long, these more numerous near anal plates; ventral surface with similar but more numerous and usually more slender setae, varying in length and size; dorsal pores including the more or less conspicuous clusters of scattered disk pores on each side of the anal plates and the nearly uniformly distributed small tubular ducts; ventral pores including quinquelocular disk pores in rows between spiracles and margin, and larger, multilocular disk pores, with the number of loculi varying from 6 to 9, beneath the anal plates; anal plates elongate triangular in outline, the caudo-lateral margin much shorter than the antero-lateral, length of one about 270μ , width about 80μ , with a distinct cicatrix at outer corner of each, with perhaps 20 tiny pores, normally bearing slender setae scattered along the inner half of each plate, with as many as 10 similar seta-bearing pores along the caudo-lateral margin to apex, with 6 ventral ridge setae arranged in pairs, with a single large fringe seta on each side and with a submedian pair of much smaller setae on the edge of the fold; anal ring small, with pores and six setae.

Larva.—As mounted, uniformly oval, length about 400 to 500μ , width about 280 to 330μ ; antennae 6-segmented, total length about 180 to 190μ , apical segment longest, third almost as long, apical seta about 80μ long; legs normal, total length about 220μ , claw with denticle, claw digitules slender, slightly knobbed, exceeding claw, one tarsal digitule inserted near tip, the other, distinctly larger and stouter, a little beyond middle of tarsus, the tips of both reaching about the same point beyond the claw as do the claw digitules; spiracles joined to spiracular spines by a row of 3 or 4 quinquelocular disk pores; marginal setae slender, more or less distinctly angularly curved, about 14μ long, spiracular spines stout, the median about 18μ long, more or less distinctly swollen at apex, the laterals globular or stout oval, about 3μ long; with two submarginal rows of small setae on each side and a single row of tiny pores between these; anal plates about 70μ long and 35μ wide, triangular, with an apical seta about 35.5μ long, two smaller setae immediately adjacent to each apical seta, a larger preapical seta and one fringe seta; anal ring with pores and 6 setae.

This species has been described from several mounted and unmounted specimens collected close to La Brea, Trinidad, beneath ant cartons on "Bois le-le" (*Cordia* sp.) by Harold Morrison on October 18, 1918 (A-803) and by C. B. Williams on November 4, 1918 (A-1025), (paratypes), and at Rio Agua Salud, Canal Zone, on Mango, in sheds of *Azteca trigona* by

W. M. Wheeler and James Zetek, March 6, 1923 (Z-1873), (holotype and paratypes).

The types are in the U. S. National Collection of Coccidæ.

The specimens from the Canal Zone differ from those from Trinidad in having a larger average size but other, presumably diagnostic, characters agree remarkably considering the distance and other barriers separating the two collection points.

***Neolecanium deramelia*, new species**

Occurring on the bark of the host, beneath ant cartons.

Adult female.—Average length about 2 mm., width about 1.75 mm., height about 1 mm. (maximum); body color, in alcoholic specimens, pale yellow to reddish brown, the small, slightly elevated mid-dorsal area bearing the anal plates somewhat darker; body normally completely covered, except for anal plates, with a thin film of whitish glassy secretion, this transparent in alcohol; body usually showing an indistinct flattened marginal area; derm, after clearing with caustic potash, showing numerous, faintly chitinized streaks and spots and, usually, around the pore and seta bases, circles of chitinized derm, but heavily chitinized only in the region surrounding the anal plates, and, to a lesser extent, along the body margin; the peculiar and outstanding feature of the dorsal derm numerous, but scattered, spear-shaped spines having a cylindrical basal portion and slender lanceolate head occupying the apical third to one half of the length; antennæ much reduced, obscurely 5-segmented, average length about 56μ , with one or more setæ on each segment and spines at apex; legs even more reduced, indistinctly 2-segmented, claw short and stout, total length about 43μ , both claw and tarsal digitules present, those of claw rather stout and knobbed, those of tarsus more slender and blunt-tipped; spiracles of normal coccine type, set well in from the body margin and with a row of widely scattered quadri- to quinquelocular disk pores between each and its marginal spiracular spines; beak very short, stout-conical, apparently 1-segmented; marginal setæ slender, tapering, about 15μ long; spiracular spines fairly stout, bluntly rounded at apices, present in threes, the median about 18μ long, the laterals around 13μ , but all varying; peculiar dorsal setæ already described about 25μ long; with some slender ventral setæ beneath and behind anal plates; dorsally with a cluster of circular disks anterior to anal plates and with minute bilocular pores scattered widely over the whole dorsal surface; ventral disk pores in spiracular region already described, those beneath anal plates larger, with 7 to 9 loculi; anal plates placed at the approximate center of the body, the cleft large and wide, each plate large, elongate, slender, triangular, but with the antero-lateral margin much longer than the postero-lateral margin, with a distinct cicatrix at outer angle, average length about 280μ , width 85μ , each with three dorsal subapical, an apical, three or, rarely, four ventral ridge and one fringe setæ, all

long and slender, and the fold with about five hypopygial setæ; anal ring small, with 10 setæ with two pairs distinctly smaller than the others.

Larva.—Broad oval, length 465μ , width 328μ ; antennæ 6-segmented, the measurements of one in microns as follows: I, 15; II, 15; III, 53;

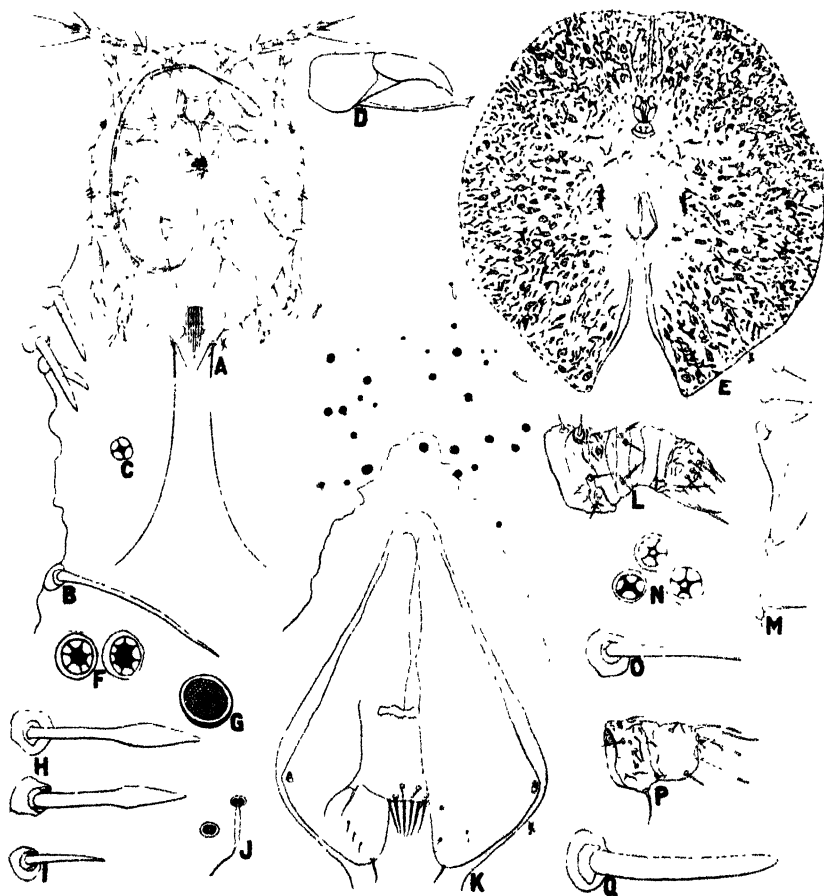


FIG. 4. *Neolecanium derameliae*, new species.

A, larva, outline from below, $\times 80$; B, same, spiracular spines and one marginal seta, $\times 1000$; C, same, spiracular disk pore, $\times 1000$; D, same, claw, $\times 1000$; E, adult female, outline, optical section, showing shape, location of parts and partial chitization, $\times 18$; F, same, disk pores from beneath anal plates, $\times 1000$; G, same, dorsal pore from near anal plates, $\times 1000$; H, same, dorsal spines, $\times 1000$; I, same, dorsal seta, $\times 1000$; J, same, minute dorsal bilocular pores, $\times 1000$; K, same, anal plates, ventral to left, $\times 153$; L, same, antenna, $\times 353$; M, same, spiracular region at margin, $\times 433$; N, same, spiracular disk pores, $\times 1000$; O, same, marginal seta, $\times 1000$; P, same, leg, $\times 353$; Q, same, spiracular spine, $\times 1000$.

IV, 25; V, 18; VI, 53; length of leg 215μ , legs normal, slender, both pairs of digitules present, slender, slightly knobbed at tips, claw with distinct denticle; each spiracle connected to spiracular spines by a row of three or four quadrilocular disk pores; marginal setæ slender, each about 21μ long, apical seta about 400μ long; spiracular spines in threes the middle more slender, about 14μ , the laterals stouter, about 8μ ; dorsum with minute bilocular pores with tubular internal duct; ventrally with submarginal rows of tiny setæ and a single such row of minute pores; anal plates elongate triangular, the antero-lateral margin somewhat longer, length about 72μ , width 32μ , with two small apical and one dorsal subapical seta, and one fringe seta; anal ring with 6 setæ and pores.

This species has been described from six mounted and several unmounted specimens collected on unknown host at Cooper's Place, Rio Aojeta, C. Z., August 19, 1923, from beneath sheds of *Asteca* sp., by James Zetek (Z-2196).

The types are in the U. S. National Collection of Coccidæ.

The conspicuous feature of the mounted insect is the peculiarly shaped, scattered, dorsal spines described above. The true relationships of the species are difficult to suggest and the generic assignment indicated above will, as already noted, probably prove to be only temporary.

Genus *Akermes* Cockerell.

Akermes cordiæ, new species

Occurring in hollow swellings of the host, sometimes attended by ants.

Adult female.—Very irregular in shape, length about 4 to 4.5 mm., width about 3 mm., height about 2-2.5 mm., color above uniform dark reddish brown, faintly mottled with lighter coloring over the disk of the dorsum, somewhat blackish around anal plates, ventral surface of body shading from light reddish brown at margin to pale yellow or even flesh color in the deeply invaginated ventral abdominal area; margin of the ventral area fairly heavily chitinized, the spiracular grooves sharply defined and deep, usually filled with waxy secretion; body surface shining, faintly rugose, indistinctly but rather uniformly pitted over disk, deeply and conspicuously pitted along margin; derm remaining yellow-brown and rather densely chitinized even after considerable treatment with caustic potash, exhibiting numerous pores of at least two kinds, the most numerous small, round to oval, apparently simple, or more or less distinctly bilocular pores, very abundant over the whole dorsal surface and, many, but less numerous, much larger, circular disk pores of indeterminate structure, each surrounded by a heavy collar and a chitinized area; the conspicuous marginal pits of the

untreated specimens appearing in mounted individuals as equally conspicuous, large, deep pits, each surrounded by a more or less distinctly thickened area in the chitin; antennæ very much reduced, length about

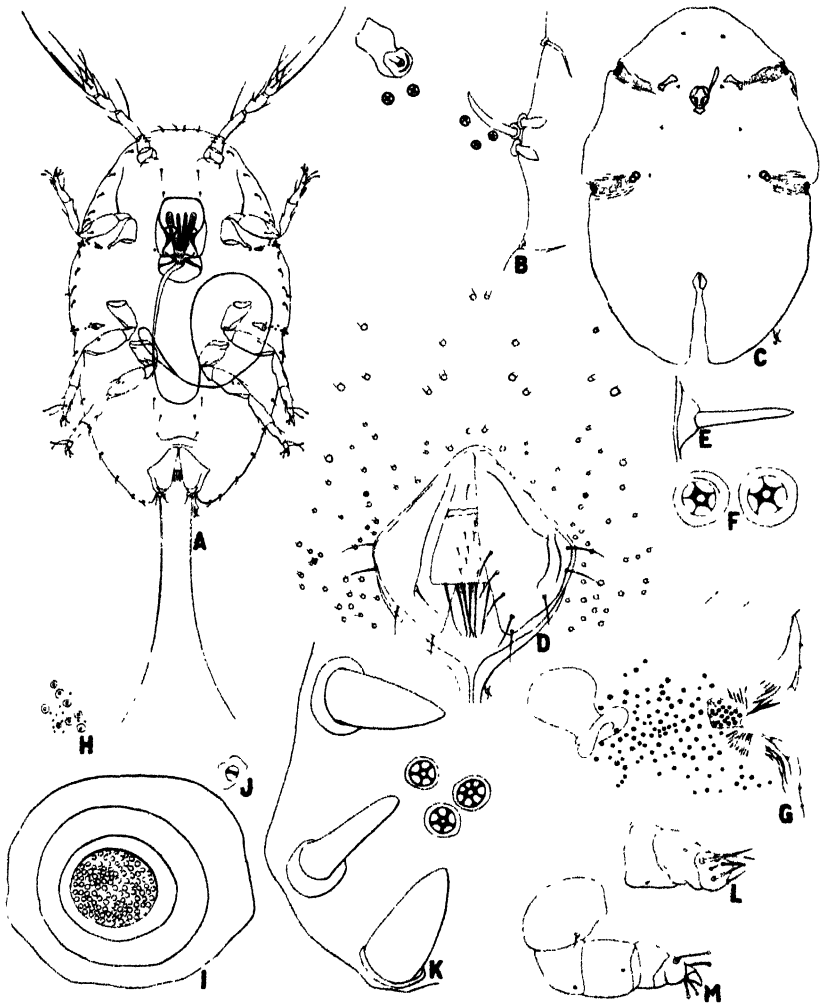


FIG. 5. *Akermes cordia*, new species.

A, larva, outline from below, $\times 80$; B, same, spiracle to margin area, $\times 433$; C, adult female, outline showing position of parts, $\times 12$; D, same, anal plates, ventral to left, $\times 153$; E, same, marginal seta, $\times 1000$; F, same, quinquelocular disk pores, $\times 1000$; G, same, region between spiracle and margin from below, the overlap of pores and spiracular spines onto dorsal surface indicated by boundary line, $\times 80$; H, same, small section of dorsal derm showing pore pattern, $\times 40$; I, same, large dorsal pore, $\times 1000$; J, same, small dorsal pore, $\times 1000$; K, same, spiracular spines, $\times 1000$; L, same, antenna, $\times 220$; M, same, leg, $\times 220$.

68 μ , width about 43 μ , very indistinctly segmented, with a cluster of spines and setae at apex; legs likewise much reduced, approximating the antennae in size, claw and tarsal digitules present; spiracles rather large, rather heavily chitinated each joined to a distinct marginal spiracular incision by a rather heavy band of pores; mouth parts small, not unusual; body dorsally with setae occasionally, these arranged in no evident order, with a considerable number of setae ventrally beneath the anal plates; marginal setae of moderate size, averaging about 14 μ in length, separated by approximately five times their own length, each placed on a small tubercle, each nearly cylindrical for much of its length then tapering to a long conical, rounded point; spiracular spines grouped in threes, all approximating each other in length, with the median usually more slender; dorsal gland pores including the large, approximately circular type of uncertain structure, already discussed, and the much smaller, circular to oval pores, likewise of rather indefinite structure; ventral spiracular disk pores mostly quinquelocular, and with a large number of disk pores beneath the anal plates, likewise normally quinquelocular and of a size approximately equal to that of the spiracular pores; anal cleft distinct, anal plates located approximately one-fourth to one-third of the body length from the posterior apex; plates approximately straight on inner margin, outer margin rounded, broadest behind the middle, length of one about 180 μ , width about 78 μ , posterior third bearing about 5 relatively long, slender setae some of these often approaching closely the postero-lateral margin, with one apical seta, with 3 to 4 ventral ridge setae, with a single quite large fringe seta, about 57 μ in length, on each side and as many as 12 hypopygial setae; anal ring with 8 setae.

Larva.—Length as mounted on slide 550 μ , width 357 μ , total length of antennae 180 μ , of leg 285 μ ; of middle spiracular spine 18 μ , of lateral spiracular spine 7 μ , of average marginal seta 18 μ , of anal plate 82 μ , width of same 43 μ , total length of apical setae 393 μ ; antennae normally 5-segmented, the third segment the longest; legs slender, not otherwise unusual, claw digitules knobbed at apices, exceeding the claw in length, tarsal digitules long, slender, thread-like, one inserted distinctly anterior to the other, both knobbed at apices and exceeding the apex of the claw; marginal setae separated anteriorly by little more than their own length, posteriorly by as much as three to four times their length, all distinctly and apparently uniformly angularly curved posteriorly; spiracular spines in threes, the median much longer than the laterals, cylindrical, slightly tapering to a bluntly pointed apex, laterally much stouter, acorn-shaped, with a few, four to six, quadrilocular or, more rarely, quinquelocular disk pores between each spiracle and the margin; with a median ventral paired row of long slender setae on the abdomen, the marginal secondary setae slender; anal plates with a slender seta on each side of the apical seta, with one fringe seta on each side; anal ring with six setae.

This species has been described from four mounted and a few unmounted adult females collected by Dr. Wheeler in

hollow swellings of *Cordia alliodora*, Ancon, C. Z., one lot (No. 114), including the holotype, not attended by ants, the other, (No. 216) attended by *Cryptocerus* (*Cyathocephalus*) sp. The larval description is based upon several mounted specimens.

Types are in the U. S. National Collection of Coccidæ.

This species has been assigned to the genus *Akermes* largely because of the lack of any well recognized genus with which to associate it. The whole complex of the Neotropical species of *Akermes*, *Neolecanium*, *Toumeyella* and various species in other genera at present forms a conglomeration of species and species names which are only rarely based on a precise morphological foundation and which cannot be satisfactorily identified nor segregated until the group to which they belong is very critically studied.

Genus *Cryptostigma* Ferris.

Since this genus evidently includes a natural group of species, the writer has accepted it for use in this paper without critical consideration of its status in relation to other described genera in the subfamily.

Cryptostigma biorbiculus, new species.

Occurring within hollow stems of the host, attended by ants.

Adult female.—Described from mounted specimens only, nothing available regarding external appearance; maximum length as mounted on slide 5 mm., maximum width 4 mm., irregularly oval, more or less distinctly narrowed anteriorly; derm apparently remaining incompletely chitinized at maturity, heavy chitinization occurring only in a band around the body margin, in the area immediately surrounding the anal plates and in two conspicuous, oval disks placed on the median line one a little anterior, the other a little posterior to the mouth parts as the latter are normally situated, derm densely crowded with small, approximately circular, chitinous disks each having a large bilocular tubular pore at its center; anterior to anal plates with a few chitinous disks of irregular shape and size each bearing a number of simple pores; antennæ very much reduced, very indistinctly segmented, with a cluster of setæ at apex maximum observed length 90 μ ; legs also very much reduced with the parts more or less evident; claw fairly well developed but small, strongly curved; claw digitules present, exceeding the claw in length; dorsal digitules present extending beyond apex of claw; average total length about 100 μ ; spiracles stout, but not conspicuously enlarged, placed quite close to the spiracular incision, the margin of each incision rather heavily chitinized and with a considerable number

of large disk pores, normally with 8 loculi between spiracle and incision; mouth parts not unusual; marginal setae stout, tapering gradually from base to apex, apex round, average length about 10μ but variable; no spiracular spines observed, these apparently wanting; no dorsal setae observed, ventrally with a considerable cluster of setae beneath the anal plates and quite a few scattered over the surface, these fairly large;

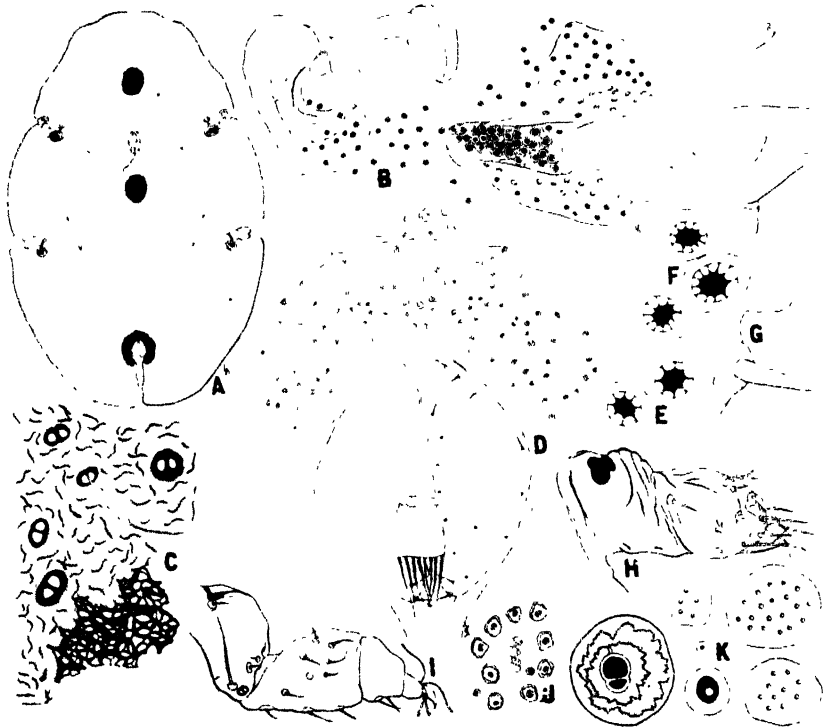


FIG. 6. *Cryptostigma biorbiculus*, new species, all adult female

A, outline, optical section, showing parts and particularly the two chitinized plates, $\times 12$; B, spiracular region of margin, $\times 153$; C, portion of one of plates showing something of structure, $\times 1000$; D, anal plates, ventral (incomplete) to left, $\times 153$; E, spiracular disk pores (2), $\times 1000$; F, disk pores from beneath anal plates, $\times 1000$; G, marginal setae, $\times 1000$; H, antenna, $\times 307$; I, leg, $\times 307$; J, portion of derm showing dorsal pores, $\times 153$; K, dorsal pores and pore plates, $\times 1000$.

dorsum crowded with 8-shaped disk pores surrounded by chitin as already mentioned, and interspersed among these many, but less numerous, single pores with narrow collar and long tubular internal duct and finally with, apparently, three paired clusters of chitinized plates each bearing several tiny tubular pores; ventrally with the large disk pores already described in the spiracular region and with transverse bands of similar disk pores around and anterior to the anal

plates these last with heavy rim and normally 10-11 loculi; anal plates each elongate half oval, length about 195μ , width about 115μ ; dorsal surface bearing about 15-18 setae scattered over the whole surface, but most numerous in a row along the inner edge, number and position of ventral ridge setae and fringe setae not determinable from material available, but with two fringe setae close to the middle line, apparently without hypopygial setae, but with the area in which these usually occur with tiny aciculations as in the species *quinquepori*; anal ring small, with pores and 10 setae.

This species has been described from four specimens mounted on slides, two from Ancon, C. Z., in *Cordia alliodora*, with *Pseudomyrma sericea*, May 5, 1923, (No. 110) (holotype and paratype), and two from Frijoles, C. Z., March 28, 1923 in the same host, with *Azteca longiceps* (No. 232) (paratypes), all collected by Dr. Wheeler. The species was also collected again by Dr. Wheeler in *Cordia alliodora*, at Corozal, C. Z., July 12, 1924, (No. 666).

The types are in the U. S. National Collection of Coccidæ.

In the characters which are available for observation this species appears to resemble Newstead's *quinquepori* quite closely; it differs conspicuously however, in possessing only two median instead of five submarginal dorsal disks. There is a further quite evident difference in the character of the dorsal pores as the 8-shaped pores of *quinquepori* are somewhat invaginated and are not surrounded by a chitinous disk as in this species.

Specimens believed to represent immature stages of this species were also collected in Ancon, C. Z., on the same date and in the same host as was the preceding material in the collection with *Azteca* sp. (No. 115).

Cryptostigma quinquepori (Newstead).

Three lots of specimens of this species have been examined in connection with this study, one collected in *Cecropia* sp., from Paramaribo, Dutch Guiana, with *Azteca alfari cecropiae* Forel by G. Stahel, and two collected in *Triplaris surinamensis* from Blairmont, Berbice, British Guiana, February 14, 1924, by H. E. Box.

The specimen from Dutch Guiana varies from the typical condition in that the intermediate "pores"—always much smaller than the other three—are apparently obsolete. No other structural differences have been noted.

***Cryptostigma reticulolaminæ*, new species.**

Occurring in hollow swellings of the host twigs, associated with ants.

Adult female.—Varying in size and shape, average length 5 mm., width 4.5 mm., height 2.5 mm., deeply invaginated beneath in the abdominal region; color of alcoholic specimens dark reddish brown with blackish infusion along margin and anterior to anal plates; body surface smooth, rather shining, bearing numerous tiny pits corresponding in position to the chitinized derm areas described later; derm remaining rather dark yellow brown after treatment with caustic potash, and showing many small, much darker, irregularly circular to oval, chitinized patches arranged in clusters to form a definite pattern, and each surrounding a fairly large pore opening, these structures apparently actually pits with dark colored wall, largest at outer surface and tapering to the small pore opening at inner end; antennæ not located in the material available, but undoubtedly very much reduced; legs extremely reduced, each represented by nothing more than a tiny patch of pores and setæ with a minute thumb-like claw and two comparatively large, slender digitules; spiracles large, closely attached to, and the structure much obscured by, the large, heavily chitinized circular to oval plate marking each spiracular region of the body margin; no definitely recognizable marginal setæ located, but setæ in the proper region slender, small, long tapering to a point; spiracular spines apparently wanting; dorsal setæ few in number, widely scattered, most numerous around anal plates, long, peg-like with bluntly rounded apices; ventral setæ small, slender, tapering, acute, more numerous than dorsal; dorsal pores including the large and small sorts already discussed, the latter furnishing the openings for slender tubular ducts, rather numerous but apparently scattered, and a considerable cluster of quinquelocular disk pores in the spiracular region, mostly in the center of the large chitinized plate; the disk pores usually found beneath the anal plates apparently lacking; anal cleft a groove only a little longer than the plates, the remainder completely obliterated; anal plates of moderate size, placed one-fourth to one-fifth of the body length from the posterior apex, length of each about 175μ , width about 110μ , shape triangular, the inner edge practically straight, the caudo-lateral edge somewhat longer than the cephalo-lateral; anterior portion of each plate more or less distinctly reticulated as in figure with three dorsal and one apical setæ on the posterior half of each plate, with three long, slender ventral ridge setæ each about 35μ , with a single, slender, fringe seta on each side about 28μ , and with six to nine relatively long, about 25μ , hypopygial setæ; anal ring with pores and 10 setæ, the longest about 125μ .

Larva.—Length as mounted 820μ , width 528μ , total length of antenna 268μ , of leg 403μ , of average marginal seta 25μ , of average spiracular spine 14μ , (all subequal), length of anal plate 107μ , width 53μ , maximum length of apical seta 55.4μ ; body rather stout oval, the derm, even in embryonic specimens, showing a pronounced irregular areolation

dorsally; antennae slender, the third segment very long; legs not unusual, the claw slender, both claw and tarsal digitules thread-like, definitely surpassing the apex of the claw, knobbed at apices and the tarsal digitules arising opposite each other; marginal setae stiff, spine-like,

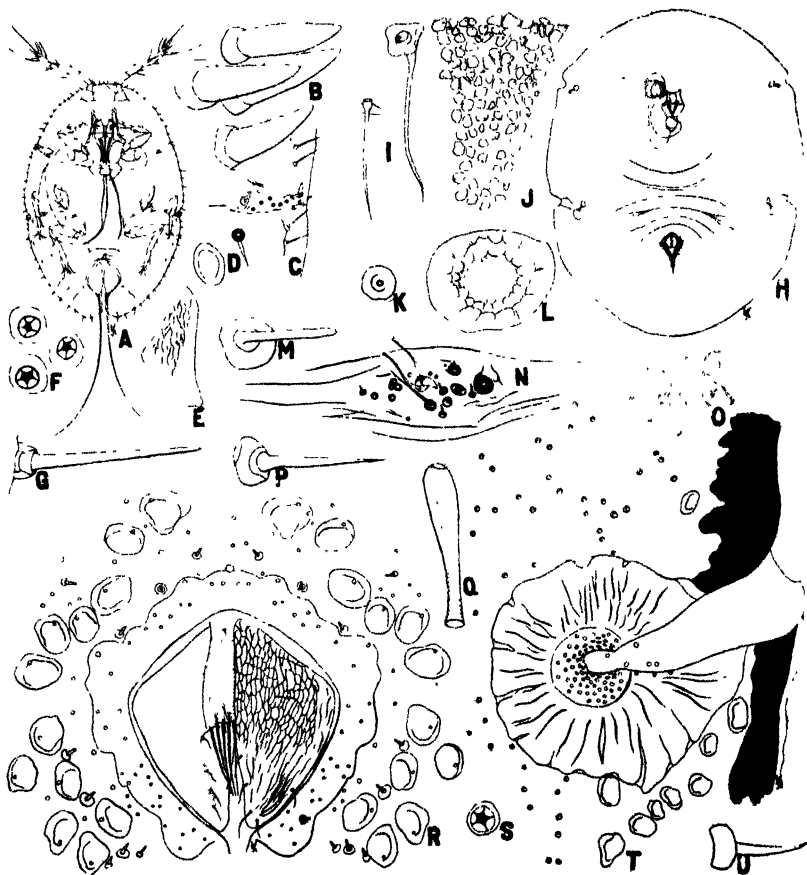


FIG. 7. *Cryptostigma reticulolamina*, new species.

A, larva from below, $\times 40$; B, same, posterior spiracular spines, $\times 1000$; C, same, spiracular region, $\times 153$; D, same, dorsal pores, $\times 1000$; E, same, anal plates from above, $\times 153$; F, same, spiracular disk pores, $\times 1000$; G, same, marginal seta, $\times 1000$; H, adult female, outline optical section, showing shape and some parts, $\times 12$; I, same, dorsal pores, $\times 1000$; J, same, portion of derm showing arrangement of heavy pores and small pores, $\times 40$; K, same, minute dorsal pore, $\times 1000$; L, same, large heavily chitinated dorsal "pore," $\times 353$; M, same, dorsal seta, $\times 1000$; N, same, leg, $\times 433$; O, larva, portion of dorsal derm showing areolations, $\times 1000$; P, adult female, ventral seta, $\times 1000$; Q, same, dorsal tubular pore, $\times 1000$; R, same, anal plates and adjacent region, ventral to left, $\times 153$; S, same, spiracular disk pore, $\times 1000$; T, same, spiracular marginal area, $\times 153$; U, same, marginal seta, $\times 1000$.

set about their own length apart; spiracular spines stout, basal portion nearly cylindrical, apex long conical, pointed, with three opposite each anterior and four opposite each posterior spiracle; spiracles not unusual, each joined to margin by a chitinized groove bearing four or five quinquelocular disk pores; derm dorsally with a submarginal row, well set in, of apparently simple pores, each with slightly chitinized rim, and with, for a larva, a considerable number of scattered, long, slender, tubular ducts; ventrally with a submarginal, an intermediate and a submedian row of setæ on each half of the body; anal plates triangular, the cephalo-lateral margin somewhat longer than the caudo-lateral; dorsal surface showing distinct elongated spindle-shaped areolations, with a short seta on each side of large apical seta, with a single fringe seta on each side, hypopygial setæ apparently lacking; anal ring with six setæ.

The adult female of this species has been described from four specimens or parts of specimens mounted on slides and the larva from a number of individuals similarly mounted. The collection data accompanying the specimens is as follows: Frijoles, C. Z., in hollow swellings of *Cordia alliodora* attended by *Azteca longiceps*, March 28, (No. 232) (holotype and paratypes); and Ancon, C. Z., in hollow swellings of *Cordia allidora* attended by *Azteca longiceps*, March 18, (No. 186) (paratypes), both collected by Dr. Wheeler. Additional collections, made by Dr. Wheeler in 1924 in *Cordia alliodora*, include one record from Agua Clara Reservoir, Ft. Davis, C. Z., July 5, (No. 607), and one from Barro Colorado Id., July 21, (No. 730).

The types are in the U. S. National Collection of Coccidæ.

This species has been placed in the genus *Cryptostigma* primarily because the spiracular complex of the adult female has at least a superficial resemblance to the arrangement found in that genus. It is by no means certain, however, that this relationship is actually anything more than superficial, and, in fact, some of the other adult and larval characters of this species diverge quite distinctly from the condition apparently characteristic for these stages of the group of species making up the genus *Cryptostigma*. However, as noted under *Akermes*, the whole classification of the subfamily including these forms is in a state which largely prohibits any discussion of the true relationship of new species.

***Cryptostigma secretus* (Morrison).**

Ferris has recently directly (in litt.) and indirectly (10, p. 283) placed his *Cryptostigma ingæ* which is identical with the

above, but was described about one month later, as a synonym of *Pseudophilippia inquilina* Newstead. This synonymy is very probably correct, but, as the writer has pointed out (9, p. 148), Newstead's description disagrees with specimens of *secretus* on a sufficient number of points to prevent their definite association. It has therefore seemed best to retain the name given above until the synonymy suggested can be definitely proved or disproved through a direct comparison of type specimens of both species.

The species is represented in the collection considered here by a single lot of material collected by Dr. Wheeler in swellings of *Cordia alliodora*, Ancon, C. Z., with *Azteca longiceps* (No. 109).

Genus **Saissetia** Desplanches.

Saissetia hemisphaerica (Targ.).

Two lots of material of this species are present in Dr. Wheeler's collection, both on young stems of *Clerodendron siphonanthus*, Balboa, Canal Zone, with *Azteca* sp., collected April 11, 1923, (No. 336, 337).

Saissetia auriculata, new species.

Occurring on the twigs of the host.

Adult female.—Length 8 mm., width 6 mm., height about 5 mm., profile along median line triangular with rounded apex, this with a single, distinct, transverse ridge; outline of body as viewed from above uniformly oval except for two somewhat protruding marginal lobes one on each side of the body near the anterior end; upper surface very dark, almost black, apparently covered by a thin film of wax secretion, shining, surface faintly rugose; ventral surface plane or slightly concave over much of its area, this portion distinctly, but not heavily, chitinized, an elongate central opening and two grooves joining this and leading to the margin beneath the little lobes, giving access to a deep, membranous, invaginated pouch; dorsal derm clearing only a little on treatment with caustic potash, showing crowded large easily detached areolations, similar in appearance to those of *Saissetia nigra* and beneath these a uniform dark brown layer bearing only tiny pores coinciding with the center of the areolations; exterior portion of ventral derm remaining yellow-brown after treatment, showing numerous scattered clear pores; antennæ small, 6-segmented, not otherwise unusual; legs small, otherwise normal; posterior spiracles small, weakly chitinized; anterior spiracles not located; mouth parts small, situated on a fleshy tubercle; no dorsal setæ located; marginal setæ stout, tapering, spine-like; both

sets of spiracular spines present, in threes, the median much larger and stouter; dorsal gland pores not noted, ventral surface with an occasional tiny tubular duct, and with a few minute quinquelocular disk pores in a loose row extending in from the spiracular spines ventrally, disk pores beneath the anal plates not located; with at least 20 and probably more submarginal tubercles around body margin; anal plates small, half oval, outer angle not even indicated, each with 4 dorsal setae at the posterior apex, one large and 4 small ventral ridge setae, and with eight fringe setae, the two outer pairs larger, the other two pairs on the fold near the middle line; anal ring small, with pores and 8 setae; hypopygial setae wanting.

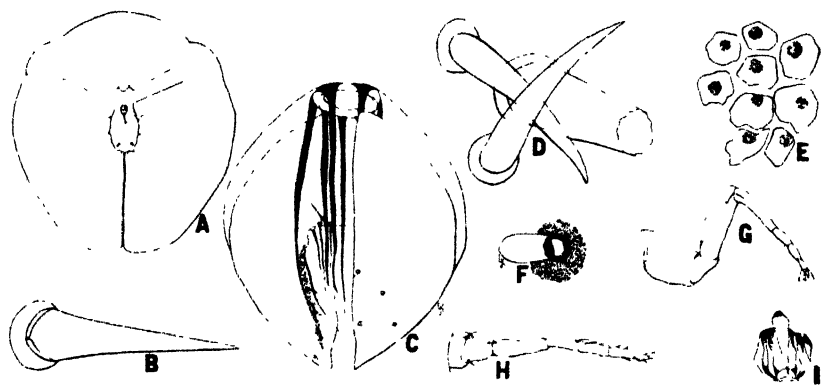


FIG. 8. *Saissetia auriculata*, new species, all adult female.

A, outline of body from beneath, showing flattened surface and boundaries of deep ventral and spiracular cavities, $\times$ about 4; B, marginal seta, $\times$ 1000; C, anal plates, ventral to left, $\times$ 153; D, spiracular spines, $\times$ 1000; E, derm areolations, $\times$ 80; F, posterior spiracle, $\times$ 80; G, leg, $\times$ 77; H, antenna, $\times$ 77; I, submarginal tubercle, $\times$ 433.

This species has been described from a single specimen collected by Dr. Wheeler at Las Cascadas, C. Z., on outside of twig of *Triplaris cumingiana*, (No. 170).

The type is in the U. S. National Collection of Coccidæ.

While it is ordinarily very poor practice to describe a species of scale insect from a single specimen, the form characterized above has seemed sufficiently distinctive to permit this course. According to present day conceptions the species agrees fully with *Saissetia*, the derm, as noted, closely resembling that of *S. nigra*, but it is readily separated from all the species of the genus known to the writer by the combination of its large size, short conical shape, with single tranverse dorsal ridge, lobe-like marginal projections and partially flattened and partially deeply invaginated ventral derm.

Genus **Cyclolecanium**, new genus.

A genus belonging in the subfamily Coccinæ and probably somewhere among the genera comprising the old section III, including the naked forms of this subfamily; exact relationships not certain, but possibly to be associated with the complex including *Akermes*, *Toumeyella*, *Necolecanium* and similar forms.

Differentiated from all genera known to the writer in that the dorsal surface proper is restricted to a relatively small, heavily chitinized disk placed in the middle of the upper face of the body, the ventral surface proper covering the remainder of the top, the sides and the under surface of the body, this modification producing an inversion and an apparent dislocation of the spiracles and the spiracular grooves; this appearance suggesting the genus *Lecanochiton* Maskell, but the available material of the latter inadequate for a critical comparative study and the resemblance apparently superficial; adult female with body, in general, flattened globular at maturity, heavily chitinized except in the mid-ventral area; legs and antennæ much reduced; spiracles located dorsally or sub-dorsally, inverted, a groove from each running inwards to the restricted dorsal surface; marginal spines short and stout, apices rounded; spiracular spines apparently wanting; true dorsal setæ apparently wanting, ventral setæ present; spiracular and ventral abdominal disk pores both quinquelocular; anal plates stout triangular, with a few apical and subapical dorsal and ventral ridge setæ, a single fringe seta on each and a few hypopygial setæ; anal ring with pores and 10 setæ.

Intermediate stage female.—With morphological details in general similar to adult, but the spiracles and their grooves in normal position, and three small spiracular spines present opposite each spiracle.

Larva.—Stout oval; antennæ normally 5-segmented, the third longest; legs not unusual; with three spines, one longer, opposite the anterior spiracles, and four, one longer, opposite the posterior; marginal setæ stout, about equalling longest spiracular spine.

Type of genus **Cyclolecanium hyperbaterum**, new species.

Cyclolecanium hyperbaterum, new species.

Occurring normally within the myrmecodomatia of the host, attended by ants.

Adult female.—Fully matured adult very high convex, usually irregular in shape, dorsal disk, that is the true dorsal surface, black, remainder of body dorsally and laterally dark reddish brown sometimes appearing almost black, this shading off more or less ventrally to a paler reddish brown then to yellowish-brown with the venter still paler; size quite variable, depending on degree of lateral compression, averaging about 3.5 mm. high, by 4.25 mm. long, by 3.25 mm. wide,

the well marked dorsal disk usually circular to elongate oval in shape and the four spiracular grooves deeply impressed and running from the sides of the body to the dorsal disk, the whole surface appearing smooth and shining as if highly polished; derm after treatment with caustic potash remaining heavily chitinized and dark reddish to yellow-brown in color; dorsal disk densely pitted by minute pores arranged in indefinite irregular radiating bands, remainder of derm with pores rather widely scattered and apparently not in definite arrangement; morphological details very largely obscured in the older specimens, most of those given therefore obtained from adult but undistended females; antennæ very short, very obscurely 4-segmented, bearing clusters of spine-like setæ at apex, total length about 35μ , width at base about 28μ ; legs small triangular in outline very much reduced, claw small, conical, digitules developed, these about four times claw length, total length of leg about 10μ , width at base 33μ , length of digitules about 14μ ; each spiracle placed at lower end of a heavily chitinized groove running between margin of the disk and the spiracle with many pores, each at the inner end of a small tube, crowded in a narrow band between spiracle and disk, spiracles not unusually large, but rather heavily chitinized and with a broad bar; mouth parts small, rather weakly chitinized; marginal setæ (along edge of disk) small, fairly stout, rather blunt-tipped, separated by about twice their own length, average length about 7μ ; spiracular spines not observed, and apparently wanting; with a few widely scattered, small, slender setæ over the lateral areas of the derm, none observed on disk, and with numerous, long, slender setæ of varying sizes ventrally beneath anal plate region; spiracular disk pores quinquelocular, ventral abdominal disk pores also quinquelocular, but larger than spiracular; with a few scattered tubular ducts present laterally, but structure of these not determinable, the very numerous minute pores of the disk possibly the openings of additional tubular ducts; disk anterior to anal plates with a small, indistinct cluster of larger circular openings somewhat suggesting in appearance the pores found in the same position in many other species of the subfamily; no structures comparable to submarginal tubercles of some species observed; anal plates placed a little behind the middle of the dorsal disk, the anal cleft distinct not fused, and continuous from the disk down around the posterior face of the body to the membranous ventral skin; anal plates triangular in outline, average length of one about 140μ , width about 70μ , antero-lateral margin distinctly longer than postero-lateral, inner margin straight or nearly so, with 4 to 5 dorsal setæ, all near the apex of the lobe, 5 to 7 ventral ridge setæ located well down from the apex, a single fringe seta on each side, and a maximum of 8 relatively large hypopygial setæ; anal ring normally bearing pores and 10 setæ, the longest about 70μ in length.

Intermediate stage female.—Much smaller than the adult, pale yellow or somewhat darker brown in dried specimens, frequently covered by a thin film of glassy secretion, flat or slightly convex, derm membranous, irregularly circular to somewhat oval, average length 1.4 mm., width 1.3 mm.; antennæ, as in adult, very indistinctly seg-

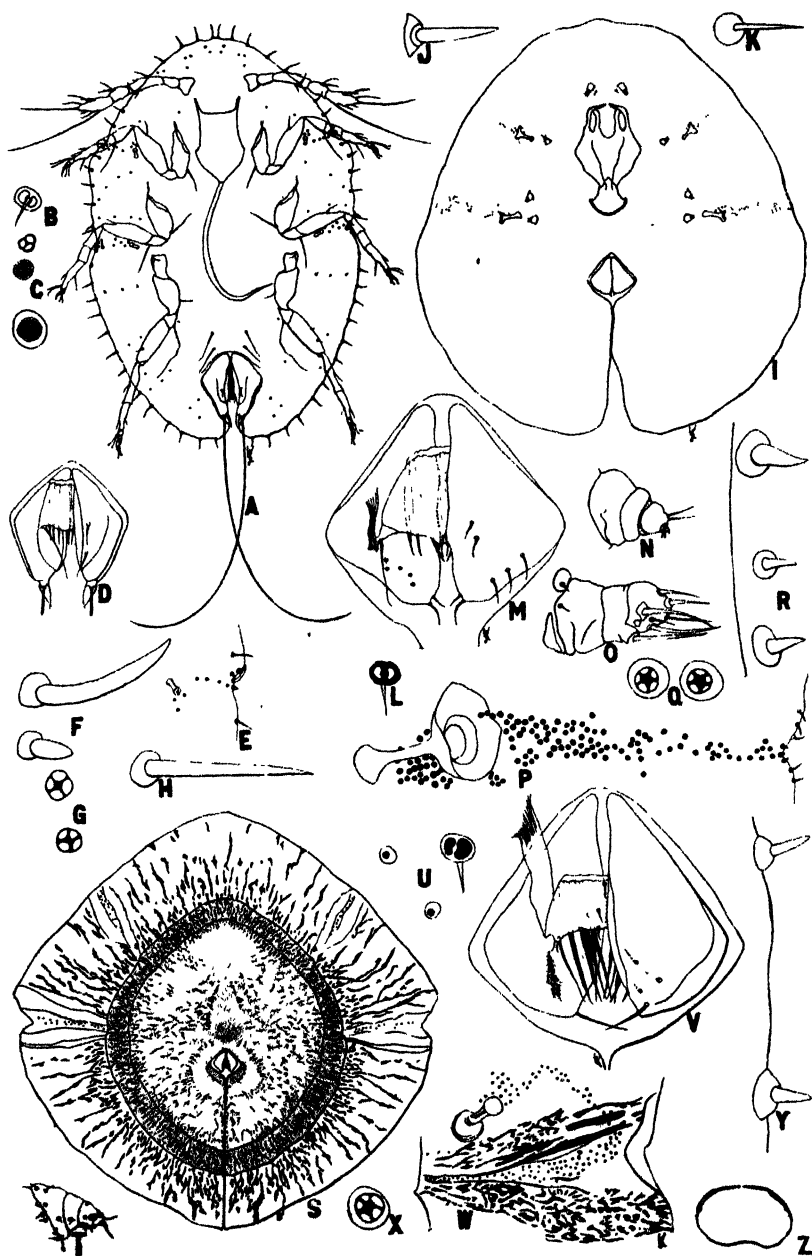


FIG. 9. *Cyclolecanium hyperbaterum*, new genus and species.

mented and bearing a cluster of rather stout spines and setæ at apex, with a maximum observed length of 35μ , and a width of 17μ ; legs very much reduced, as in adult, short conical, with four distinct parts, claw conical, claw digitules present, tarsal digitules thread-like about 14μ long; spiracles normal in shape, with slender bar and expanded outer end, mouth parts not unusual, beak very short, stout and apparently 1-segmented; marginal setæ separated by approximately twice their own length, rather stout, each about 12μ long, pointed at apex; spiracular spines represented by a set of three elongate conical spines shorter and stouter than the marginal setæ, placed opposite each spiracle; dorsally with a considerable number of scattered slender setæ averaging distinctly smaller than the marginal setæ, ventrally with some slender setæ beneath the anal plates and near the antennæ at least; dorsally with numerous, but scattered, tiny bilocular pores distributed rather uniformly over the body surface; ventral spiracular disk pores quinquelocular; anterior row from anterior spiracle to margin incomplete; anal plates located a little behind the middle, in general resembling those of adult in shape, with about 3 or 4 dorsal, 4-6 ventral ridge, one fringe seta to each plate and a total of 3 or 4 hypopygial setæ; anal ring small, with 8 setæ and some pores.

Larva.—Average length as mounted 640μ , width 450μ , length of apical seta 44.5μ , average marginal seta 21μ , longest spiracular seta 21μ , small spiracular seta 7μ ; total length of antenna 190μ ; length of parts of middle leg in microns: coxa 78, trochanter 30, femur 100, tibia 64, tarsus 57, claw 22, claw digitules 23, tarsal digitules 36; body uniformly oval; antennæ normally 5-segmented, III the longest; legs slender; mouth parts normal; spiracles oval each with a single row of quadrilocular disk pores between it and margin; marginal setæ relatively large and stout, acutely pointed; anterior spiracular spines in threes, the median about two or three times the length of the others, posterior spines usually in fours, with one much longer and one very slightly larger than the other two, more rarely in threes as in the anterior spiracle; body with a few ventral setæ but apparently without dorsal

EXPLANATION OF FIGURE 9.

A, larva, outline from below, $\times 77$; B and C, same, body pores, $\times 1000$; D, same, anal plates, ventral to left, $\times 153$; E, same, spiracular region, $\times 153$; F, same, spiracular spines, $\times 1000$; G, same, spiracular disk pores, $\times 1000$; H, same, marginal seta, $\times 1000$; I, intermediate stage female, outline, optical section, $\times 40$; J, same, marginal seta, $\times 1000$; K, same, dorsal seta, $\times 1000$; L, same, bilocular pore, $\times 1000$; M, same, anal plates, ventral to left, $\times 220$; N, same, leg, $\times 353$; O, same, antenna, $\times 353$; P, same, spiracular-marginal region, $\times 353$; Q, same, spiracular disk pores, $\times 1000$; R, same, spiracular spines, $\times 1000$; S, early adult female, before distension, outline from above, $\times 18$; T, same, leg, $\times 220$; U, same, dorsal pores, $\times 1000$; V, same, anal plates, ventral to left, $\times 220$; W, same, spiracular-marginal region from left side of body, $\times 40$; X, same, spiracular disk pore, $\times 1000$; Y, same, marginal setæ, $\times 1000$; Z, same, hypothetical cross section through anal plates and posterior spiracular region, showing position of true dorsal surface and the inversion and apparent dislocation of the spiracles.

setæ, although with scattered 8-shaped pores dorsally; anal plates rather elongate slender, inner margin straight, the anterior- and posterior-lateral margins about equal in length, with a very long apical seta and two much shorter subapical setæ, one on each side of the larger; anal ring with six setæ.

This species has been described from 17 lots of material collected by Dr. Wheeler in 1923, in hollow swellings of *Cordia alliodora* at Ancon, C. Z., accompanied by *Pseudomyrma sericea* (No. 110); by *Camponotus* sp., (No. 210); by *Azteca longiceps* or *Azteca* sp., (No. 108, 109, 115, 186, 214 and without number); at Red Tank, C. Z., accompanied by *Crematogaster* sp., (No. 147); by *Azteca* sp. (No. 67); by *Azteca longiceps* (No. 65, 66, 141, 186 2nd lot); at Frijoles, C. Z., accompanied by *Azteca longiceps*, (No. 235); at Barro Colorado Island, accompanied by *Azteca longiceps* (No. 201) and at Pueblo Nuevo, Panama, accompanied by *Azteca longiceps* (No. 297). The holotype, an early adult female, is from lot No. 110. The remaining specimens are paratypes. Further collections, made by Dr. Wheeler during the summer of 1924, have established the following additional records for this species. In *Cordia alliodora*, Agua Clara Reservoir, Ft. Davis, C. Z., July 5, (No. 607); in *Cordia alliodora*, Gamboa, C. Z., July 9, (No. 642); in *Cordia alliodora*, Barro Colorado Id., July 21 (No. 730), and Aug. (No. 832); Ancon, C. Z., Aug. 6 (No. 847). The species occurred alone or in company with one or more of the other species discussed in this paper.

The types are in the U. S. National Collection of Coccidæ.

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THE MATING FLIGHT AND THE VESTIGIAL STRUCTURES OF THE STUMP-LEGGED MAYFLY, *CAMPSURUS SEGNIS* NEEDHAM

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MATING SWARM.

At Kartabo the waters of the Cayuni meet those of the Mazaruni and soon join the great lake-like Essequibo flowing north through the low lying country of British Guiana until it runs into the sea at Georgetown. These rivers are hedged in by the jungle whose undergrowth has invaded the border waters in a persistent attempt to gain more territory. Mangrove roots swing so far out from the banks that fish swim in and out among them. Moccamoccas, the giant arums, have grown out still further. Their clublike stems standing in close rank provide on gigantic scale the kind of animal shelter furnished in more modest form by our own arrow head and pickerel weeds. Many slow flowing creeks feed into these larger streams but their mouths are hidden by creepers, tangles of mangrove, and prickly shrubs, and if the currents are gentle enough they are choked by lush growths of Cabomba.

The mouths of these creeks are flooded every day and the floor of the jungle bordering the shore is covered with water for several feet back from the river by the rise of the fresh water tides. Even at Kartabo Point the daily tides are insistent reminders of the ocean forty miles away. The low tides lay bare stretches of muck and ooze, silt and silty sand, the constant siftings from the side currents of the stream. This silt is soft and loose, rich in organic material. Wherever it occurs in all our more familiar lakes and streams it is the likely dwelling place of nymphs of the burrowing and crawling Mayflies which belong to the subfamily Ephemerinæ including the largest and most familiar Mayflies such as *Ephemera* and *Hexagenia* and the white winged *Polymita*rcys. Among its members is the little known tropical genus, *Campsurus*. Though not absent from smaller streams the burrowers frequent

lakes and rivers where they live in just such silty bottom as that of the Mazaruni and Essequibo. On the Mazaruni side of Kartabo Point there is a short stretch of beach and along it the low tide leaves a band of silt which indicates the nature of the bottom over which the side waters of the Mazaruni flow. Even a glance at this shore would suggest the prediction that burrowing Mayflies might live nearby.

In the late evening of July 8, 1926, Mayflies of the species *Campsurus segnisi* were flying in large numbers, above this beach. Burrowing crickets were running, or digging into the moist sand, left where the tide had gone out. They were bewildered by the spotlight and lost their direction if not their speed. Suddenly a shower of Mayflies began falling across the beams of light. In the first glare they looked like the white winged *Polymita* of a genus already mentioned. Most of them protested against their fall and their wings fluttered, snowy and opaque. On the sand they toppled helpless. Many fell with outspread wings which at once clung closely to the wet sand; others were tipped over like capsized sail boats. All of them were prone. None had been able to negotiate the ground surface. As they came into the light most of them fluttered straight down from the height of twelve to fifteen feet at which they must have been flying. A few came into view at a low level, evidently borne along near the surface of the water by the breeze coming in from the river. For half an hour they kept falling upon the sand. Then the Mayfly shower ended with the same suddenness with which it began.

Was this a mating flight of fully matured imagoes or a company of subimagoes which had but just shed their nymphal skins and flown toward the light? Their differing maturity seemed to indicate a mixture of both mating and emerging flights. The cause of the ground flop was seen as soon as one of the Mayflies was picked from the sand. The females did not at first appear to have any legs at all. Only two males were found and these were lying with their front legs extended before them but they were as devoid of other legs as the females and nearly as helpless. This dearth of males argued against there having been any mating flight in progress, since with Mayflies that is characteristically a male performance. In the lake species, *Ephemera simulans*, the flight is predominantly male while in the small species, *Choroterpes basalis* and *Baetis posticus*, males make up at least half of the swarms. The

females of *Campsurus* were borne down to the ground by their heavier bodies and the weight of their eggs, while it may have been that the lighter bodied males had flown on into the trees. This seemed the more probable because many of the females had yellow packets of eggs projecting from the openings of the oviducts. Such egg packets are carried by many kinds of Mayflies and their appearance always indicates that the short span of adult life is about over, that mating has occurred, or if not, at least that full maturity has been reached and the eggs can no longer be retained. One of the Mayflies which is most commonly seen carrying egg packets is the tiny *Caenis* which is often caught and hung, eggs and all, in the meshes of spider webs upon bridges and street lamps. The egg masses of *Campsurus* were carried not only by imagoes which had shed their subimago skin entirely but by those over which the subimago skin still fitted completely or partially. When the egg packets were removed from these females, the walls of the oviducts were found far everted with the Malpighian tubules pushed through the membranes and hanging into the air as if the eggs had been forced out so convulsively that the ducts had been torn and the tubules projected through their walls. The females collected had probably swarmed and had been flying over the water to deposit their eggs when they were carried in toward the light.

The subimago stage of *Campsurus segnis* is probably of brief duration, far different from that which is characteristic of its related *Hexagenia bilineata* and *Ephemera simulans* in which this stage lasts twenty-four hours or more. In these and in many other species this subimago period is the one in which there is a rapid elongation of the legs and caudal setæ. These changes are most obvious in the males, the lengthening slenderness of whose front legs is zigzagged across the encasing subimago skin as if in a stocking much too short. No such growth of the legs seemed to have occurred in these *Campsurus* subimagoes.

In the extreme specialization which *Campsurus segnis* has attained the brevity of its aerial life has been a necessary parallel to the abbreviation of its legs. The adults are entirely dependent upon their wings for existence. Since they have no legs to rest upon neither males nor females can alight upon anything and if they are forced down there is little chance that they can ever fly again.

VESTIGIAL LEGS AND MODIFICATIONS FOR REPRODUCTION.

In 1876 Eaton published his "Notes on the legless condition of *Campsurus*" and very briefly commented upon specimens of "*Campsurus* and some of its allies" in which all of the legs had been cast off by some of the females, while in others the front pair of legs had been retained "as it had seemingly in all the males." (Eaton 1876, p. 7). In his "Revisional Monograph of Recent Ephemeridæ" he characterized the genus and described eight species but neither in genus nor species descriptions did he mention the extreme atrophy of the legs which he had previously noted (Eaton 1868, 1876). Although he carefully defined the color of the legs of species of *Campsurus* and referred to the "fore legs yellowish like the hinder legs" in the females of *Campsurus decoloratus* Hagen (Eaton 1883, p. 41) he made no comment as to any vestigial condition. He figured the head, wing, genitalia and front leg of the imago male *Campsurus albifilum* Walker (Eaton 1883 Pl. V., Fig. 8a) but did not there mention any peculiar condition of the middle and hind legs. In 1913 a figure of an unnamed species of *Campsurus* was published by the author (Morgan 1913 p. 394). This was drawn from a specimen kindly loaned by Dr. J. G. Needham. This male imago showed the vestigial middle and hind legs very clearly but some of its structures were broken and so far as the author is aware no description of it has been published. Under the caption, "An Adult 'Peg-leg' *Campsurus* sp?", Dr. Needham included this figure in his interesting paper (Needham 1920, Pl. LXXXI, Fig. 57) on the burrowing Mayflies of the subfamily Ephemerinæ. In connection with his key to this subfamily he pointed out that "*Campsurus* alone has the middle and hind legs aborted," (Needham 1920, p. 277). In his key to the adults, (Needham 1920, p. 277), *Campsurus* was set off by the venational characters, "posterior fork of the median vein in the forewing very deep, almost reaching the base of the wing; two long simple intercalary veins between the first and second anal veins," (Pl. I, Fig. 7).

Campsurus segnis was first described in the paper. "Neotropical Mayflies" by J. G. Needham and H. E. Murphy 1924. At Dr. Needham's suggestion a further description of it has been included here, together with figures of the male and female imago. The extremes of specialization which are its significant aspects will first be discussed.

This form and the genus to which it belongs present an extreme in the development of those parts directly or indirectly concerned with reproduction and a relative suppression of those not necessary to that end. The whole tribe of Mayflies includes many similar but less striking examples and the wings, front legs, and caudal setæ are always modified for action in the vertical flights undertaken during the Mayfly mating dance. Corresponding parts are less specialized in the more conservative females. Mayflies have developed mechanisms which are extremely efficient in these unique flights during which they mate. They are poor and unwilling walkers and no Mayfly can run. Their legs are always slender and delicate, giving only a weak support to the body which in many species is carried mainly by the middle and hind legs, the front ones, especially in the males, being held forward in an attitude of cordiality with no reference to locomotion or support. Observation of the male individuals of *Siphonurus*, *Heptagenia*, *Ephemerella* or *Chironetes* will show the small part which the front legs take in supporting the body and will indicate their tendency to have less and less to do with the work of walking. This general ineffectuality of the legs for their original function and the shift in the use of the front legs of the male into structures accessory to mating is but a hint of the extreme disparagement of pedal locomotion which occurs in *Campsurus*.

In *Campsurus segnis* the middle and hind legs of the male are but stumps made up of three poorly defined segments, the terminal ones being pointed and heavily chitinized at the tips. (Pl. I, Fig. 2). These legs are too short to be of any use. When alive the insects are able to move them only a little and even when the legs have been pushed ventrally by force their tips hardly reach to the underside of the thorax. The front legs of the male are similar and not proportionately longer than those of males of other related forms of the *Ephemerinae*. As is usual in Mayflies there is a twist in the joint which articulates the first tarsus with the tibia; this allows the supination of the tips of the front legs which are clasped about the female in mating. The male approaches the female from beneath and throws his front legs upward about her thorax, bending the tip of his abdomen upward, so that its ventral side comes so closely in contact with that of the female that the forceps may clasp her abdomen and the hooks of the penis, (Pl. I,

Fig. 5), be extended into the openings of the oviducts between the seventh and eighth segments.

The front, middle and hind legs of the female *Campsurus* are all aborted stumps each consisting of three weakly defined segments, (Pl. I, Fig. 4). The front legs are shortest and consist like the others of what is probably coxa, femur and tibia. What first appear to be the coxæ of the third legs are elevations of the thoracic wall, (Pl. I, Fig. 4). The ventral views of both the male and female thorax make the legs appear further ventral than they really are, (Pl. I, Figs. 2, 4). The side view of the male (Pl. I, Fig. 1) gives a truer picture of their position as it obtains in both sexes. Among the sixty females examined there were five in which one leg was noticeably longer than its mate, (Pl. I, Fig. 4). This plasticity of the leg form was further demonstrated by one female in which the left front leg was long enough to reach the front margin of the head and included a well grown femur, tibia and tarsus with tarsal claw although the corresponding front leg had but three ill defined segments and happened to be even shorter than the average, (Pl. I, Fig. 3). Reversion like this, and such irregularities of size and form are characteristic of vestigial structures and here they are good evidence of the unsteadiness of this extreme specialization which has not yet become firmly implanted in the pattern of the organism. Among Mayflies it represents an extremity of the reduction of the standing and walking function of the legs, and the predominance of degenerate limbs among which more normal ones still make their appearance.

Here pedestrianism has become as much a matter of the past as food getting became long ago among adults of the whole Ephemerid society. *Campsurus segnisi* is similar to related species, such as *Hexagenia recurvala*, (Murphy 1922, Pl. VI, Figs. 88-98), in the atrophy of its mouth parts. In the female here figured all of the mouth parts are easily seen except the labrum, (Pl. I, Fig. 4). The long soft processes of the mandibles are usually crossed above the mouth cavity in which the papilla like hypopharynx is visible. They are similar to those of species of *Hexagenia* and *Ephemera* and other burrowers, and are the vestiges of the tusk like rami of the mandibles. The unknown nymph of this species must have such mandibular tusks. (Nymph of an unknown species of *Campsurus*. Needham and Murphy, 1924, Plate IV.) These atrophied mandibles

showed clearly in both of the captured males but were more shrunken in them than in the females, a difference which may have been due to greater maturity or to individual variation.

Like other Mayflies this species has long caudal setæ, held stiffly extended behind in flying, outriggers especially long in the males; in *Campsurus segnis* they are three times the length of the body. But the unique specialization of *Campsurus segnis* remains in the abbreviation of legs of which it is a superlative example.

Description of *Campsurus segnis* Needham

Male imago (Pl. I, Fig. 1). (Alcoholic specimen). Length of body, 10 mm.; length of setæ, 32 mm.; front legs, 4.5 mm.; middle legs, 1 to 2 mm.; hind legs, 1 to 2 mm.

General color pinkish buff, becoming subhyaline on the abdomen with brownish shadings, ridges brownish. Head, unevenly brown; eyes uniformly dark brown, small, oval and widely separated; lateral ocelli distant from each other, larger than the median ocellus; antennæ with the terminal segment hair-like and longer than the other two together. Thorax, pinkish buff, translucent; mesonotum with a broadly triangular spot of brown; metanotum tipped with brown. Wings hyaline (Pl. I, Fig. 7), costal border brownish; costa, subcosta, and radius of the front wing and costa and subcosta of the hind wing brown. Front legs with femur and tibia brown, equal or subequal in length; fore tarsi whitish, the joint between the tibia and tarsus appearing like a short segment; middle legs vestigial with three poorly defined segments, the terminal one pointed; hind legs similar to the middle pair, but slightly longer, (Pl. I, Fig. 2), legs sometimes variable in length and asymmetrical. Abdomen brownish with pale sutures, flecks and dashes; a pale mid-dorsal line extending through segments 3-10; a corresponding but more distinct line on the ventral side; conspicuous elevations on segments 2-8, each terminating at the hind angle of the sternite, showing the former position of six of the nymphal gills, (Pl. I, Fig. 1). Setæ two, hyaline, sparsely plumose at the tips. Forceps inserted each upon a separate base distinct from the posterior margin of the ninth sternite, and with a short process extending lateral to each forceps limb, (Pl. I, Figs. 5, 6). Penis strongly chitinized, curved ventrally above a pair of shorter, club-shaped processes which broaden into the spoon-shaped subgenital plates, (Pl. I, Fig. 6).

Female Imago.—Encased in subimago skin but sexually mature with the oviducts everted and abdomen cleared of eggs. (Alcoholic specimen). Length of body, 9 mm.; length of setæ, 18 mm.; length of front, middle and hind legs, each less than 3 mm.

General color buff, brownish shadings on abdomen, ridges brown. Head unevenly brown; eyes oval, same size as in the male; ocelli obscurely banded with brown, the lateral ocelli distant from each other and larger than the median one. Pronotum pale; mesonotum with

brown markings confluent in a triangular spot; front legs aborted into short stumps with three poorly defined segments, (Pl. I, Fig. 4); middle and hind legs likewise aborted and segmented but slightly longer than the first pair; legs sometimes asymmetrical, (Pl. I, Figs. 3, 4). Abdomen with lateral elevations in segments 2-7 marking the positions of nymphal gills. Setae two, hyaline to whitish, not plumose at the tip as in the male.

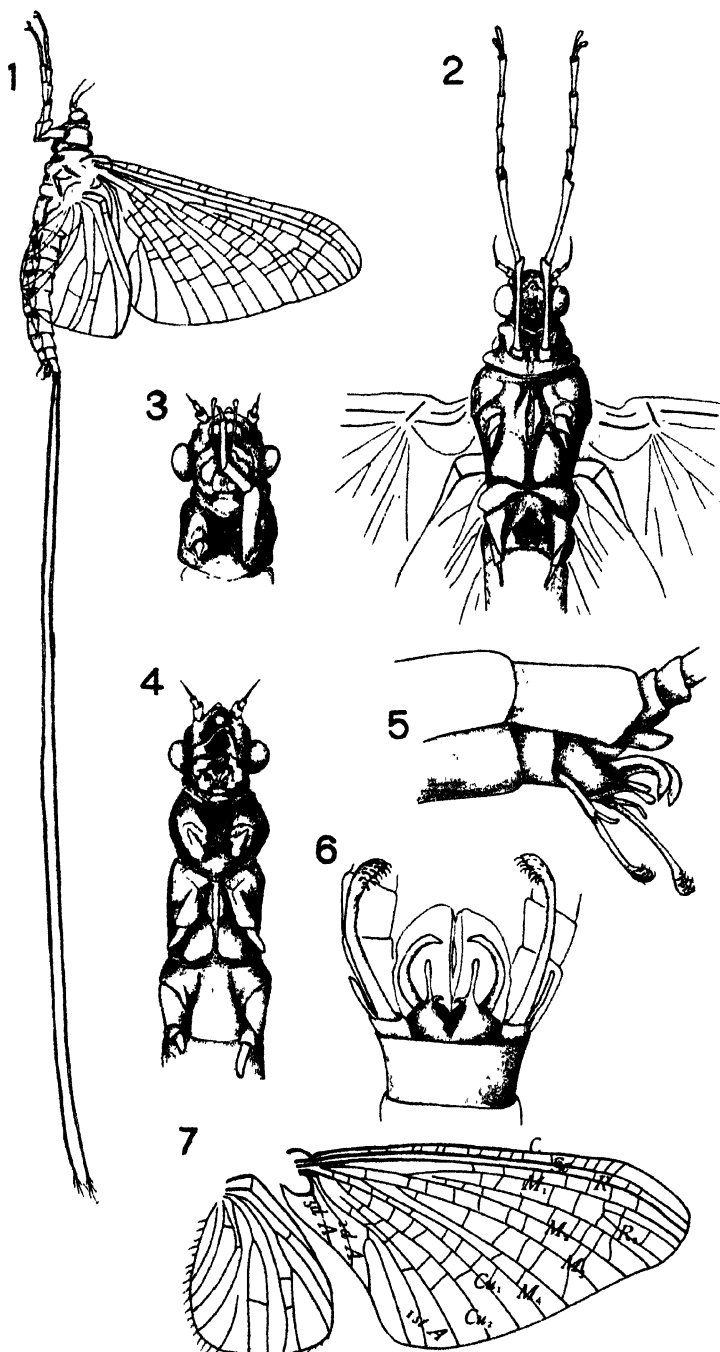
Described from two males and ten females taken at Kartabo, British Guiana, July 8, 1926. The nymph is not known and no specimens nor molted skins of it were discovered.

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EXPLANATION OF PLATE.

- Fig. 1. *Campsurus segnis* Needham. Adult male, showing vestigial middle and hind legs. Note the lateral elevations on the abdomen.
- Fig. 2. Ventral view of adult male, showing the three segments of the vestigial legs. Front legs with four tarsi, and a twisted joint between the tibia and tarsus which allows the supination of the tarsi.
- Fig. 3. Ventral view of adult female, showing asymmetry of the front legs. The vestigial mandibles have their rami extended forward.
- Fig. 4. Ventral view of adult female, showing the vestigial condition of the legs and a common asymmetry. Note the vestigial mouth parts; clypeus, (labrum not visible), mandibles, maxillae, labium, and the papilla-like hypopharynx showing within the mouth cavity.
- Fig. 5. Side view of male genitalia, showing each forceps limb flanked by a short process and the double penis curving ventrally over the extensions of the subgenital plates.
- Fig. 6. Ventral view of the same. Note the incurving hooks upon the median edges of the subgenital plates. The plates on either side of the anus shown in outline appear disproportionately large when the body is in this position.
- Fig. 7. Front and hind wing of *Campsurus segnis*. Veins named by homology with those of Hexagenia, (Morgan 1912). Note the depth of the posterior fork of the median vein.



THE REPRODUCTIVE SYSTEM OF THE WARBLE FLY *HYPODERMA BOVIS* DEGEER.

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The studies upon which this article is based were undertaken at the Ohio Experiment Station several years ago. The determination of the flies from which the drawings were made was verified by J. M. Aldrich as *Hypoderma bovis* De Geer. This year the illustrations were checked with specimens of *H. bovis* de Geer furnished by E. W. Laake.

In the main, my studies confirm those of Carpenter and Hewitt (1914). In the specimens that I studied, however, a few structures were observed that are not noted by Carpenter and Hewitt. For example, they describe only one male accessory gland while two accessory glands were present in my specimens. (Fig. 8, A. G.). Imms (1925 p. 607) evidently bases his statement "in *Hypoderma* there is a small unpaired globular (accessory) gland" upon Carpenter and Hewitt's observations.

The writer also observed a variation in the degree of chitinization of the various urites composing the postabdomen from that figured by Carpenter and Hewitt. The difference is especially noticeable in the paired "styles" (S. Figs. 4 and 5) which in the writer's specimens resembled more nearly those figured by Carpenter and Hewitt from *H. lineata* de Villers. The central area is less heavily chitinized and more transparent. Relative to the degree of chitinization, I suspect the variation may possibly be due either to difference in the age of the insect or in the length of time the specimens are kept in the sodium hydroxide solution. The writer also has numbered some of the urites differently.

METHODS OF WORK.

Freshly killed specimens and dried pinned specimens were used in this investigation. The dried pinned specimens were relaxed by placing the abdominal segments in boiling water for a few seconds. The postabdominal segments were removed

from the pre-abdominal segments by severing the coria with a fine needle under a binocular microscope. The postabdomen was then placed in a 10 per cent sodium hydroxide solution, boiled for a half hour or so and then left in the caustic solution for several days. The specimens were then thoroughly washed in water and run through the alcohol up to 85 per cent and gradually into glycerine. All of these operations except boiling in the hydroxide solution were carried out in Syracuse watch glasses. The specimens were examined in the watch glasses by means of a binocular microscope. The examination in glycerine in the watch glass permitted the observation of every aspect of the postabdomen which is not possible when it is mounted upon a microscopic slide.

THE MALE ABDOMINAL SEGMENTS.

For convenience the abdomen is divided into two divisions, the preabdomen and postabdomen.

The preabdomen is assumed to contain urites one to five. The first urite it is assumed is fused with the thorax and is not visible. The preabdomen then consists of four visible segments, urites 2 to 5, that are entirely exposed. They are subequal in size and the largest segments of the abdomen. The fifth tergite and sternite are subequal in length and breadth. The fifth sternite is less convex and more deeply incised on the meso-caudal margin than is the fifth tergite (Fig. 1, St. 5 & T. 5). The postabdominal segments are partially, a few entirely, hidden by retraction within the fifth urite (Fig. 1).

NUMBERING OF THE SEGMENTS

The numbering of the remainder of the segments of the abdomen is based upon the following assumptions:

1. The anus opens primitively between the eleventh tergite and its corresponding sternite.
2. The genital orifice is primitively between the ninth and tenth sternites, though the development of the penis may carry it to a point without any evident relation to the tenth urite.
3. In the diptera the style bearing segment is the tenth.

THE POSTABDOMEN.

Urite Six.—The first segment of the postabdomen is designated as the sixth segment. Of this segment the tergite alone is distinct. It is a fairly well-developed sclerite, although comparatively short and narrow. (Fig. 5, T. 6).

Urites Seven and Eight.—The tergites of these segments apparently are present though not recognizable as such in what Carpenter and Hewitt have named the intersegmental conjunctiva or coria between

the sixth and the ninth tergite. This conjunctiva, although brown in color, is not as heavily chitinized as are tergites 9 and 10. It is thickly covered with hairs similar to those covering the preabdominal segments and undoubtedly constitutes the major portion of the postabdomen normally exposed caudad of the fifth tergite. A spiracle which I take to be the eighth is located on each lateral margin of this intersegmental membrane near its line of union with the sixth tergite, (Fig. 5, Sp. 8).

Sternite Eight is the most extensive part of the ventral exoskeleton of the postabdomen. It is narrowly rounded cephalad and broad behind. Laterally its edges are produced into delicately pointed processes, almost completing a circular ring dorsad of the genital armature. It is divided into two parts: an anterior small triangular-shaped area and a posterior larger shield-shaped darker brown area. (Fig. 5, St. 8). The line of demarcation apparently is the point of attachment of the intersegmental membrane. Both Bruel and Lowne believe that the pregenital sternum belongs to the eighth segment and C. & H. agree as regards its hinder edge at least. However, if the genital orifice is between the ninth and tenth sternites, this sternite should be the ninth. There extends from the caudal edge of this sternite a pair of blunt finger-like processes, the anterior gonapophyses. (Fig. 5, G. 8).

Urite Nine is a most highly developed and interesting segment, and the largest of the postabdominal segments. It appears to consist of a single highly specialized sclerite. The highly convex tergite extends latero-ventrally into a pair of prominent processes, the styles, (S, Fig. 5). The ventral edge of each process is continued forward into a narrow chitinous band which touches the dorsal edge of the pregenital sternum, (Fig. 5, St. 8). The ninth urite is also produced ventrally on each side into chitinous triangular extensions, the apices of which nearly meet ventrad of the tenth sternite. I have named this portion of the ninth urite, sternite 9, (Fig. 4).

Also from the proximal ventro-lateral edge of the ninth tergum a relatively broad membranous sclerite extends ventro-cephalad and joins the lateral edge of sternite eight. This sclerite in its lateral aspect is crescent-shaped. In conformity with Carpenter and Hewitt's nomenclature, I have called this sclerite an epipleuron, although I question whether it is to be regarded as homologous with the pleura of the thorax. Rather I suspect it to be a part of one of the post-abdominal urites, (Fig. 5, ep.).

Tenth Urite.—In the specimens examined by the writer this segment is divided into a small delicately chitinized quadrangular sclerite (T. 10), immediately caudad of the ninth tergum and a larger and more heavily chitinized sternite (St. 10), which is quite unique in structure.

The *Tenth Tergite* is separated from the ninth tergite by a very narrow indistinct suture. Its meso-distal margin is deeply incised; laterally it articulates with the tenth sternite.

The *Tenth Sternite* (St. 10) in its dorsal aspect is subtriangular in shape, the base of the triangle deeply emarginate, the apex bluntly pointed. Between the basal emargination and the tenth tergite occurs

a thin pale membranous expansion of cuticle arranged in folds. The anus is located in the middle of this cuticular membrane. Evidently this membrane represents the eleventh urite, (U. 11). The tenth sternite is prolonged into a ventrally directed point, (Fig. 5). It is beset with many short spines. The dorsal aspect of the tail region differs considerably with the angle at which it is viewed. (Figs. 2 and 3).

THE MALE REPRODUCTIVE ORGANS.

The *Testes* are small white pear-shaped bodies, each 1.25 mm. long and 1 mm. wide. They are located in the caudal portion of the second abdominal segment, one on each side of the meson. One of the bodies apparently is slightly more caudad than the other. Each testis is opaque and when compressed a white semen-like fluid discharges. (Fig. 8, R. T. & L. T.).

The *Genital Ducts* (Vasa Deferentia). (Fig. 8, V. D.).—Posteriorly each testis tapers into a slender vas deferens, one of these which we will designate the right vas deferens (r. v. d.) is longer than the left (l. v. d.). (R. V. D. 3.5 mm. to 4 mm. long; L. V. D. 2.5 mm. long). The right vas deferens passes under the cloaca and joins the left on the left side of the cloaca, forming what is commonly called the vesicula seminalis by dipteran anatomists. Thence a common duct passes cephalad, then caudad a total distance of 5 mm., passing dorsally over the rectum, then ventrad entering the ejaculatory sac on the ventral side, (Fig. 5, D. e.).

The *Accessory Glands* (Mucous Glands), (Fig. 8, A. G.).—In the region where the two vas deferens unite are situated two small pear-shaped bodies, 1 mm. long and about 0.75 mm. broad. Each is joined to the vesicula seminalis by means of a very short duct.

The *Copulatory Organ* (Aedeagus, Penis).—The innermost part of this organ is an enlarged sac, the ejaculatory sac; constricted in the middle and bulb-like at each end, (Fig. 5, S. e.). The walls of the sac are supported by a peculiar chitinous sclerite of irregular shape. I did not observe the two recurved hooks on the caudal end noted by Carpenter and Hewitt. This sclerite is broad and scoop-shaped at both ends and restricted in the middle. (Fig. 9). Posteriorly the sac is continued caudad into the proximal end of the ejaculatory duct which traverses the penis.

The *penis* consists of a tubular colorless sheath supported by a tubular sclerite, the *Theca* or *Juxta*, (Fig. 6, Th.). This sclerite projects cephalo-dorsad and caudad. The theca is continuous around the base of the organ and is produced dorsally into a strong median spine, (S., Fig. 6), the "superior apophysis" of Gordon Hewitt in the house fly. Caudally the theca extends along the sheath in paired lateral processes, terminating in hooks, (Figs. 4 and 5). Adjacent the hooks on the ventro-lateral aspect of the penis is a pair of short, narrow chitinous supports, (Th. 2).

On either side of the theca is a conspicuous chitinous process hooked at the caudal end and articulating apparently with the chitinous processes at the proximal end of the sheath, (G. 9). These are called

the "posterior gonopophyses" in agreement with Carpenter and Hewitt and Lowne.

Each posterior gonopophysis articulates with a heavily chitinized process, the tips of which are somewhat complexly hooked. Each sclerite is directed laterally and lies partially hidden by the caudal edge of the pre-genital sternum. The ventro-mesal horn of each of these processes is fused with the base of the anterior gonopophysis of the same side. Likewise a chitinized horn from each of the processes extends dorsad for a short distance along the theca on each side of the penis. Agreeing with Carpenter and Hewitt, I have designated these processes as the *outer posterior gonopophyses*, (G. 9, 2).

The *anterior gonopophyses* consist of a pair of blunt finger-like processes projecting caudad from the posterior edge of the pre-genital sternum and lying on either side of the penis, (G. 8). The bases of these gonopophyses are united with the chitinous edge of the pre-sternal plate, and are continued into the strong median *great apodeme* (Ap.), "inferior apophysis" of Gordon Hewitt, which runs cephalad ventral to the ejaculatory duct. The apodeme is also continuous with the theca or sheath of the penis, which together with the other processes forms an especially complicated heavily chitinized basal rim, by which apparently the penis is rotated or articulated. The shape of the great apodeme in the specimens examined by the writer is more paddle-like than "spoon-like," as described by Carpenter and Hewitt.

THE FEMALE ABDOMINAL SEGMENTS.

The abdomen of the female may likewise be divided into two divisions, the preabdomen and the postabdomen.

The preabdomen is similar to that of the male. It consists of five segments, four of which, urites 2 to 5, are visible. The postabdomen, urites 6 to 10 or 11, is modified into a cylindrical tube which is called the ovipositor. The urites are joined together by means of long flexible intersegmental membrane or coria, making it possible for the segments to be telescoped in one another from behind forwards: the eighth, ninth and tenth into the seventh, the seventh into the sixth, and all then telescoped into the fifth.

The *Sixth Urite*, (6, Figs. 10, 11).—The tergite and sternite of the sixth segment differ but slightly from those described by Carpenter and Hewitt. The cephalic margin of the tergite in the specimens observed by the writer is not as completely rounded; the cephalo-lateral margin is concave and the union with the lateral margin is pointed rather than rounded. The sclerite is broader behind than in front. The sternite is broader in front than behind. Both the cephalic and caudal edges are emarginate.

The *Seventh Urite*, (7, Figs. 10, 11).—The seventh tergite consists of two slender elongate sclerites similar in shape to those figured by Carpenter and Hewitt. The sternite likewise consists of two slender sclerites more closely apposed than are the tergites, differing from Carpenter and Hewitt, who described only one sternal sclerite in *H. bovis*.

The *Eighth Urite*, much shorter than those preceding it, has two tergal sclerites, broad cephalad, pointed caudad and two long sinuate sternal sclerites. The caudal extremities of these sclerites are rounded and beset with short sharp spines, forming the ventral boundary of the tip of the ovipositor. (T. 8, St. 8, Figs. 12, 13).

The *Ninth Urite*.—The sclerites of this and the tenth segment have probably become fused, making it difficult to homologize them. Following Carpenter and Hewitt, I have designated the shield-like paired lateral sclerites the ninth sternites, (St. 9) and the proximal part of the last tergite, tergite nine. (T. 9, Fig. 14).

On the sides the tip of the ovipositor is bounded by a pair of blunt, curved, hooked-like sclerites. Each articulates with the caudal edge of sternite 9 and the lateral margin of tergite 9. Carpenter and Hewitt regard these sclerites as out-growths of the ninth segment and analogous to what I have designated the "styles" in the male, (P. 9). I agree with Carpenter and Hewitt that they are not cerci which are appendages of the eleventh segment.

The dorsal part of the tip of the ovipositor is bounded by tergite nine and ten. This sclerite is the largest of the sclerites forming the tip of the ovipositor. In its dorsal aspect, it is broad in front, tapering caudally to a narrow neck, then expanding. Its dorsal aspect reminds one somewhat of a tenpin. At its extremity this sclerite is directed ventrad, ending in a point. Together with the paired lateral sclerites (P. 9) and paired rounded ends of sternite 8, (P. 8), this sclerite surrounds the vulva opening beneath the eighth segment, and all five sclerites are joined by coria which is stretched when the egg is being laid. Then the tergal plate and lateral plates are directed dorsalward, the sternal plates remaining almost horizontal. The shoe or flange of the egg is directed dorsalwards. The writer has observed that *H. bovis* when laying eggs pushes the ovipositor almost vertically down among the hairs of the host, thus confirming Glaser's '13 observation. On the other hand, *H. lineata*, according to Glaser, holds its ovipositor nearly parallel to the skin of the host animal.

The caudal edge of each segment of the ovipositor is fringed with a circle of hairs, and the intersegmental cuticle between the sclerites has a beautiful reticulate black and white pattern, as pointed out by Carpenter and Hewitt. The intersegmental membrane is closely studded with curious short spines with broad bases and one, two, or three points each. The points are directed forwards when the ovipositor is extended. (Fig. 16).

THE FEMALE REPRODUCTIVE ORGANS.

The Ovaries and Oviducts.—The ovaries of *H. bovis* (Fig. 19), present the characteristic tufted appearance observed by Carpenter and Hewitt. My specimens, however, being fixed in formalin did not permit the observation of the structure of the ovaries in detail as they report. Nevertheless, they seem to be of the same general structure. Each ovary is made up of many ovarioles. The ovarioles open, singly or by two, threes or fours into what may be termed secondary ovarian tubes,

which join together to form larger tubes, ultimately about 5 or 6 main ovarian tubes unite to form an oviduct. Each ovary in the specimens examined by the writer seemed to be made up of two distinct groups of ovarioles. The ducts leading from each join to form the oviducts. But this apparent difference from the structure of the ovaries described above might have been brought about by pressure in the abdomen of the female since the specimens were fixed in situ.

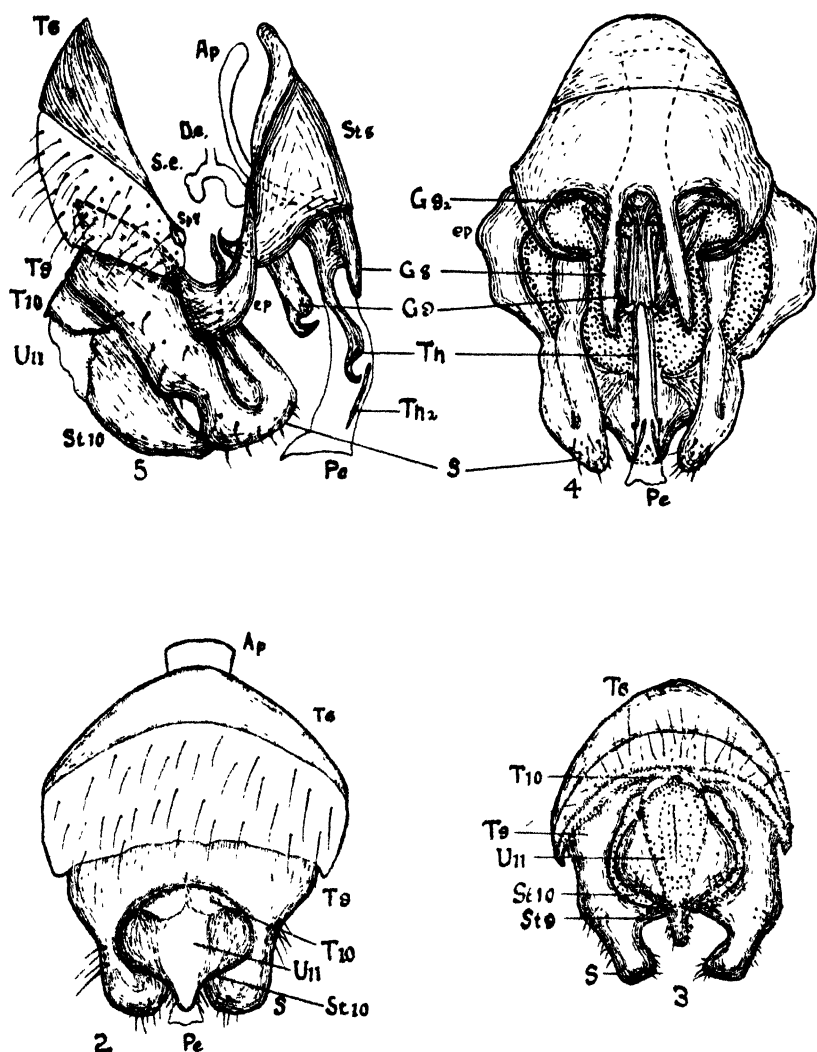
The egg in the ovariole is already surrounded by the shell with its grooved flange-like process for attachment to the host-animal's hair. Throughout its progress from the ovariole to the vulva the egg moves with this process directed caudally. The right and left oviducts leading respectively from the two ovaries, unite to form a common oviduct which merges into the vagina. (Fig. 17, Od.). The latter opens into the bursa copulatrix at the end of the ovipositor. The common oviduct and vagina form a subcylindrical tube nearly filling the cavity of the postabdominal segments. My specimens were fixed with the ovaries in situ, the ovipositor having first been extended. Upon dissection I found both the right and left ovaries and a portion of the right and left oviducts in the general abdominal cavity. The extreme tips of the ovaries reached nearly to the anterior end of the abdomen.

The *Spermatheca* (Fig. 17, 18 sp.).—Typical of the calypteræ, the spermatheca comprises three dark brown chitin-lined sacs each with a duct also chitin-lined opening close together in the mid-dorsal region of the vagina. The wall in the terminal portion of each duct is dilated slightly. Two of the spermatheca are located on the right of the oviduct and one on the left. On the walls of the spermatheca, transverse ridges and dark spots may be seen which, according to Carpenter and Hewitt, are chitinous ridges and small recurved hooks. The hooks are outside the chitin and in contact with the thin outer fibrous sheath of the spermatheca.

The *Accessory Glands* (colleterial glands), (Figs. 17, 18, A. G.)—One pair of long tubular accessory glands are found in *H. bovis*. They arise in the preabdominal cavity in the region of the ovarioles and open apparently into the distal portion of the vagina. They function probably in providing a cement-like secretion which serves to fasten the egg to the hair of the host.

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Hypoderma bovis, male, $\times 42$.

- Fig. 2. Dorsal aspect of postabdomen
Fig. 3. Dorso-caudal view of postabdomen.
Fig. 4. Ventral view of postabdomen.
Fig. 5. Lateral view of postabdomen.

Explanation of Lettering: T6, tergite 6; T9, tergite 9; T10, tergite 10, U11, urite 11; St10, sternite 10; S, styles; ep, epipleuron; Sp8, spiracle 8; S.e., ejaculatory sac; D.e., ejaculatory duct, Ap., great apodeme; St8, sternite 8; G8, anterior gonopophyses; G9, posterior gonopophyses; G9a, outer-posterior gonopophyses; Th, theca or juxta; Th2, theca.

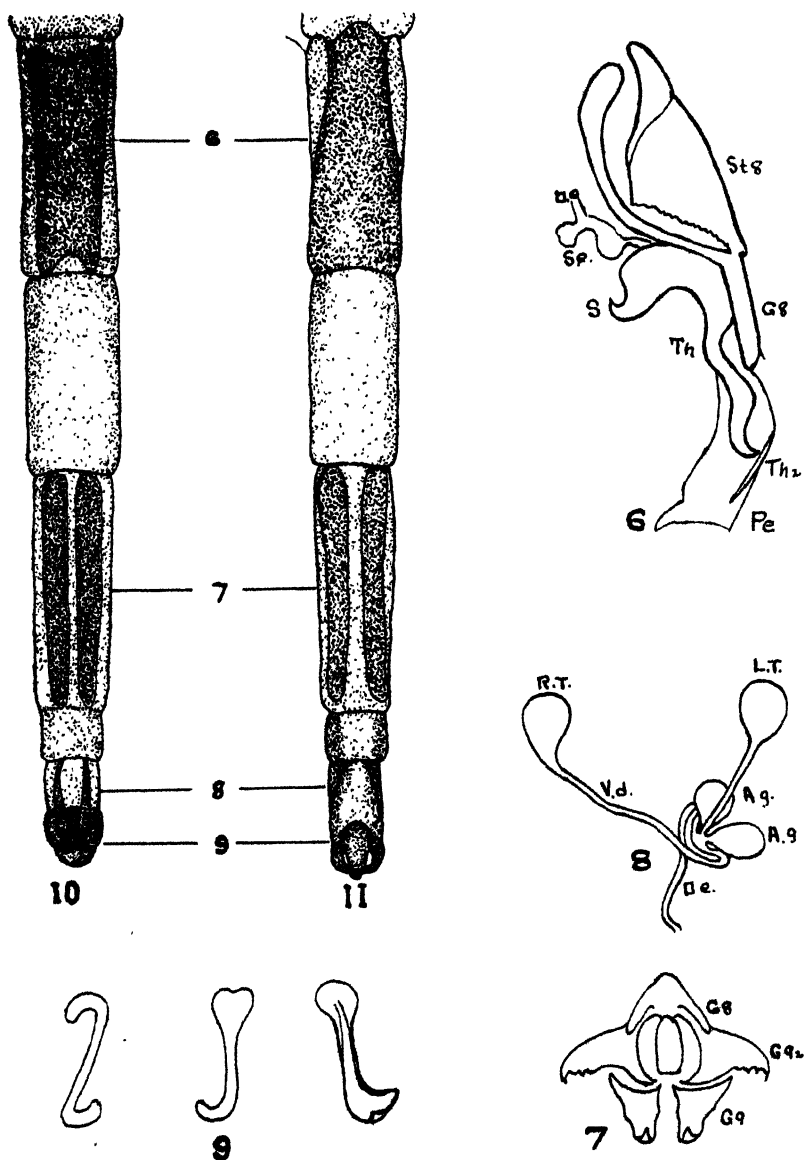


Fig. 6. Penis and Associated Structures. S, median spine of theca. $\times 40$.
 Fig. 7. Gonopophyses, caudo-ventral view.
 Fig. 8. Male Reproductive Organs. $\times 6$ R. T., right testis; L. T., left testis;
 V. d., vas deferens; A. g., accessory glands; D. e., ejaculatory duct.
 Fig. 9. Various view of the chitinous support of the ejaculatory sac. $\times 50$.
 Fig. 10. Ovipositor, ventral view. $\times 10$.
 Fig. 11. Ovipositor, dorsal view. $\times 10$.

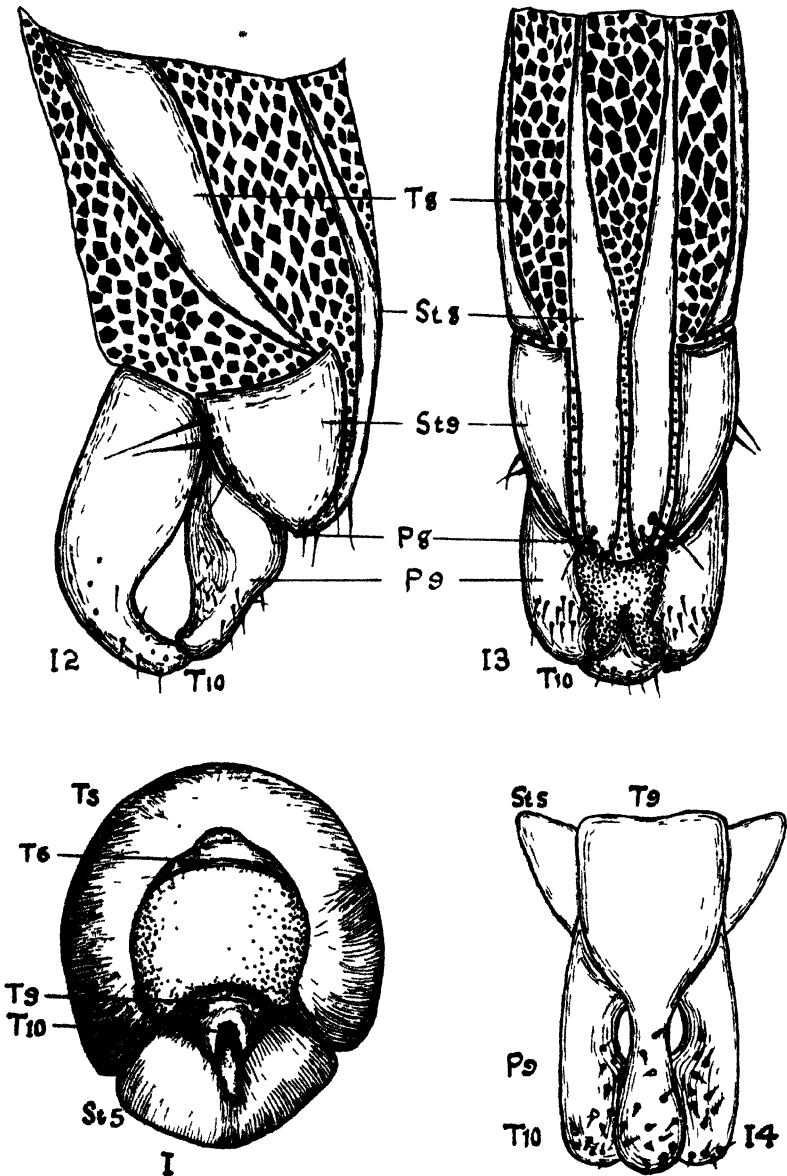


Fig. 1. Caudal aspect of the abdomen of the male ×14

Fig. 12. Terminal segments of the ovipositor, lateral view. ×80

Fig. 13. Same, ventral view. ×80.

Fig. 14. Tip of ovipositor, dorsal view ×80.

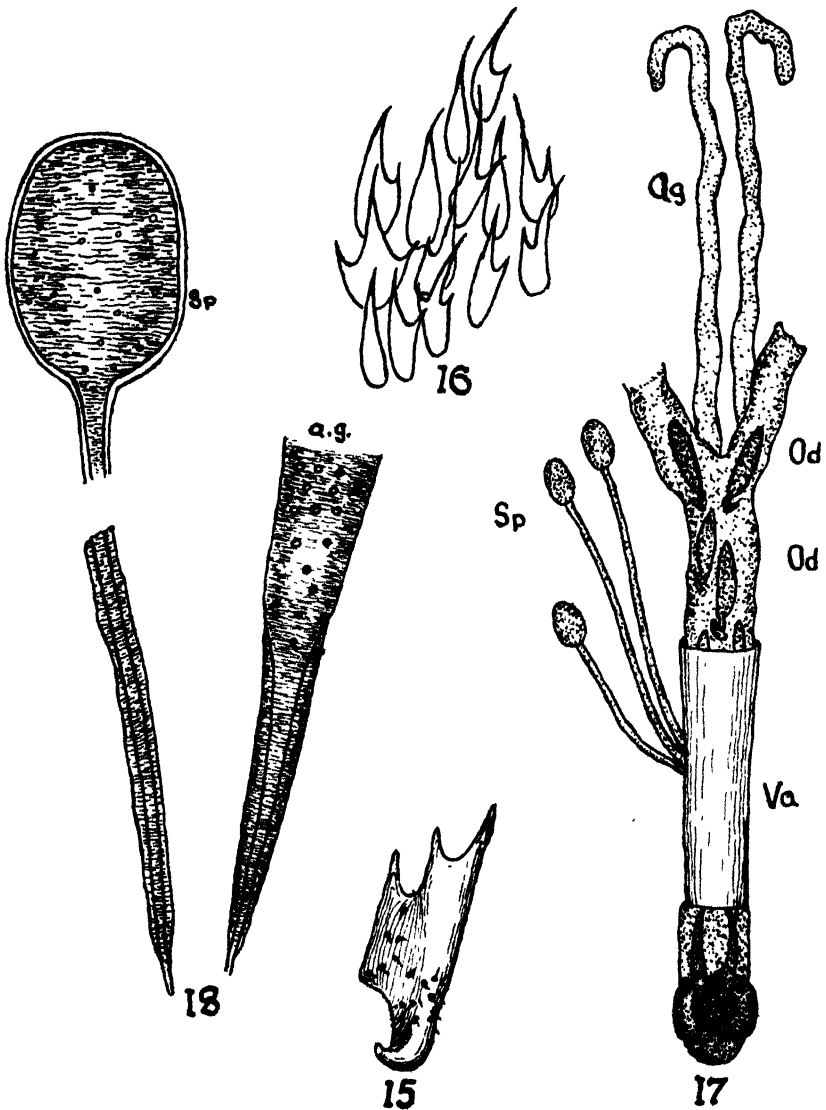


Fig. 15. Lateral view of gonopophyses. P 9. $\times 80$.

Fig. 16. Spines of the intersegmental membrane. $\times 300$.

Fig. 17. Female reproductive organs. $\times 10$. Ag, accessory glands; Od, oviduct; Sp, spermatheca; Va, vagina.

Fig. 18. Spermatheca and accessory gland. $\times 50$.

NEW GENERA AND SUBGENERA FROM THE GENUS DELTOCEPHALUS.

A Study of the Internal Male Genitalia of the American Species and Their Bearing Upon Taxonomy.*

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Some two years ago the senior author constructed and published a key to the North American species of *Deltocephalus*,† using external characters in an attempt to form a working basis for this group. During this study several problems in taxonomy and relationship presented themselves and had to remain unsolved for the time without an examination and detailed comparative study of internal characters. The present treatment, discussion and figures, is an attempt to throw more light upon these relationships by presenting the structures and data which will assist in solving some of these problems and establishing certain taxonomic relationships among these species.

On the basis of characters used in the previous treatment the genus was divided into a number of subgenera. For this division, wing, head and external genital characters were used. One of the problems in mind in the present study and treatment was a critical study of these divisions which were made formerly. It would seem from the evidence at hand that this division into groups was correct as far as they were established, but that still others should be set off because of certain unique characters, or groups of characters.

Another phase of the generic problem has also entered this discussion, that is the relationship of long established genera which are closely related to the genus *Deltocephalus* as it was formerly recognized, to the different subgenera as set off recently by the senior author. It is apparent from previous and present study that certain genera like *Thamnotettix*, *Euscelis*, *Lontura*, and others of this general group are more

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closely related to certain of these subgenera than some of the subgenera are to each other, especially the extreme groups. It seems logical therefore to term these groups genera in the future and they are thus treated in the following discussion. Also two new genera and two subgenera are established. For many years species that could not be disposed of otherwise were placed in the genus *Deltocephalus* and it is time that these were separated into their proper groups.

There remains little doubt concerning the question of where to place the species recently known as *Thamnotettix nigrifrons* Forbes which was separated from its apparent close relatives because of the absence of a second cross vein in the wing. This small group of *Thamnotettix* belongs with the subgroup carrying the *Deltocephalus* name and containing such species as *vanduzeei*, *balli* and *fuscinervosus*. Furthermore, certain *Thamnotettix* species, like *inornatus*, are undoubtedly closely related to the *Laevicephalus* group, while several species of *Euscelis* and *Lonatura* are closely related to species of the *Amplicephalus* group.

Genus **Flexamius** De Long.

(Plates I, II and III).

The genus *Flexamius* was erected by the senior author and this division was based largely upon the character presented by the reflexed costal veins of the first pair of wings. Several rather distinct subgroups were noticed in this subgenus showing diverse types of genitalia which were illustrated previously. In the former treatment these were placed together since external structures alone were considered of necessity. As might be expected when establishing a group chiefly upon a wing character, great diversity is found in the structure of the internal genitalia throughout this group upon examination of these structures. In several cases this is so marked that doubt arises concerning the placing of certain of these species in the same subgenus and even their probable separation into more diverse grouping. At the same time this condition may be due to a loss of or our inability to locate intermediate forms.

The styles probably show less variation than the other internal structures, but in most cases these show specific differences. The terminal processes exhibit the greatest specific

variations regarding size, length and curvature. In some species a spine-like process is present on the anterior lateral corner. The articulation with the connectives also presents slight specific differences. In a lateral view the lateral dorsal folding of the styles is rather prominent in most species. *Abbreviatus* and *surculus*, with their wide blunt apices with angled margins, are quite different from the more pointed apices of the other species of the group as regards the styles.

The oedagus varies greatly throughout the group, especially as regards the terminal processes and is probably the best internal character for specific separation as well as showing those species which are more closely related. The body of the oedagus may be long or short, rather even in width throughout its length or tapering from anterior to posterior ends. The terminal processes may be two in number, same size and type, three in number different size and type, and either single or bifurcate.

From this study some of the more interesting relationships might be pointed out, as well as some of the unique and striking differences. The study would indicate that there have been certain developments in different directions from a generalized type, and these groups which have developed in different ways seem to contain certain species more closely related to each other than to the other species.

Pectinatus appears to be of this generalized type. The oedagus is simple in form and devoid of terminal processes. *Abbreviatus* appears to be rather closely related to *pectinatus*, the oedagus being of the same type but somewhat heavier. The styles of this species on the other hand with the wide blunt apices are different and unique for the group with the exception of *surculus*. It is doubtful where this latter species should be placed, but it shows evidence of being closely related to *abbreviatus*. The styles and bifurcate anterior processes of the oedagus of *surculus* are of the same general type, although the bifurcate terminal processes are similar to those of the *albidus* group.

Four of the species examined, *pictus*, *pyrops*, *sandersi* and *visendus*, each have a pair of terminal processes on the oedagus and are different in this respect from the other species discussed here. *Pyrops* and *pictus* are very similar in view of the pair of tapering terminal processes on each, and their anterior

dorsal processes of the oedagus. *Pyrops* seems to be only an extreme form of this type of oedagus structure. The styles are different in shape and are proportionately larger in the case of *pyrops*. The pygofer of *pictus* in the region just dorsal to the plates are drawn out into long, triangular, pointed structures which overlap. The other two species examined with two terminal processes, *sandersi* and *visendus*, are quite similar in structure and have been confused because of their external resemblance. The terminal processes of the oedagus are of the same general type and armed with barbed processes, but are distinct. In *visendus* these processes are much longer and broader. The styles are almost identical. The anterior processes of the oedagus are distinct, being hooked or bent at right angles in the case of *sandersi* and straight in *visendus*. One of the best specific characters is found in the pygofer since in *visendus* the edges are serrated and overlap in the region just dorsal to the plates, which condition is not found in *sandersi*.

Specimens of *stylatus* have not been available for dissection, but the styles are so long in this species that they are visible without dissecting. They are long, black and conspicuous, exceeding the blunt plates. This character as shown in Ohio State University Bulletin, Vol. II, No. 13, Plate IX, 5b, is an excellent one for external use.

Inflatus, *flexulosus* and *areolatus* show another diversion in having three terminal processes on the oedagus. In *flexulosus* the three processes are short and of the same type and size, while in *inflatus* two are of the same size and type, lateral in position and resembling somewhat the two processed species, but the third is of different type and much longer. The extreme of the three terminal processed character is apparently reached in *areolatus*, where one process is longer and appears heavily clothed with coarse pubescence, while the shorter two are smooth. The styles are very similar to the other species like *sandersi*. In *slossoni* and *albidus* the pair of bifurcate terminal processes of the oedagus shows some similarity, but not necessarily close relationship since other characters are quite different. In *slossoni* the body of the oedagus attains its greatest width in the middle while in *albidus* the oedagus is wide at the ends and narrow in the middle. The anterior processes of the oedagus in *albidus* are distinct, their caudal

extremities being expanded into wide bulb-like structures. The styles are different specifically. Furthermore in *slossoni* the terminal fourth of the oedagus curves ventrally and anteriorly, terminating in a rather sharp point. This condition is unique among those species of *Flexamius* examined. A sharp spine-like process which is also unique is found on the ventral side of the oedagus posterior to the articulation with the connectives. In view of these characters and the wing condition a new subgenus is described here and *slossoni* is placed as the type of this group.

Subgenus **Secopennis** nov.

(Plates II and III).

Head produced and flat as in *Flexamius*. Elytra broad and flaring venation somewhat similar to *Flexamius* with the reflexed costal veins present but with posterior margin of elytra sloping obliquely from the claval vein and slightly concavely rounded to the costal margin forming a produced portion on the costal margin which is rounded at the apex. The inner apical cells are very short as seen in the figure of this venation which is given in the monograph of *Deltocephalus* Plate IV for *slossoni*. This species is designated as the type of this subgenus.

The species is so different from the *Flexamius* group that it has seemed advisable with further study to place it in a separate subgenus.

Subgenus **Palus** nov.

(Plate IV).

Elytra with a definite but small appendix, central ante-apical cell constricted at center but not divided, outer ante-apical cell quite small, sometimes almost obsolete, two or three costal veins slightly reflexed. Vertex somewhat variable in length and degree of angle. Margin of vertex not sharply defined as in *Flexamius*. The external genital characters of the four known species of this group are very similar in both the males and females.

All of these species live on sedges or coarse grasses of the fresh water marshes and all occur in northern habitats.

Type of subgenus *delector*.

The males of only one species have been available in sufficient numbers for dissection.

In *delector* the only species of this apparently diverse group which was available or sufficiently abundant for dissection,

these structures show still further differences. In general form the styles are not greatly different from the generalized type. The oedagus from a lateral view is narrow at the base soon enlarging abruptly dorsally at the top of which a pair of long spine-like processes extend ventrally one either side to the ventral side of the oedagus. Although heavily chitinized on only the ventral side, the oedagus is thickened to the posterior end, tapering slightly to a bluntly pointed tip. A slight spur extends dorsally near the tip. In dorsal view the oedagus is slightly constricted on the central half, the most unique portion being the apex, which is enlarged, with a pair of diverse pointed tips, a pair of barb like spines extending anteriorly at the anterior point of enlargement. This group is apparently quite different from the preceding ones mentioned if we may judge from this species which externally resembles very closely the others which are placed here.

Genus *Alapus* nov.

(Plates II and III).

Vertex similar to *Flexamius* but more strongly produced, usually almost twice as long as width between eyes. Elytra with several cross veins in clavus and middle anteapical cell usually divided into three or more cells. Male pygophers with flapper like structures attached to posterior margin inside of genital chamber and extending forward when in normal position.

Fraternus and *mendosus*, which differ markedly from the *Flexamius* group in the characters mentioned above, as well as the strikingly different external genital characters, are placed in this genus. *Fraternus* is designated as the type.

The internal genitalia although very similar in these two forms seems to give slight specific differences.

Mendosus and *fraternus* have been commonly confused and if species, they are undoubtedly very closely related. The oedagus, although similar and variable in both species, seems to be distinct. It is rather short and comparatively broad, not tapering, terminating very bluntly. At about the middle a pair of wing-like processes are given off which from a side view are continuous dorsally. From a ventral view the oedagus appears to rest on a bifurcate structure which is attached to the wing-like structures anteriorly, apparently without a direct connection. The two processes of this bifurcate structure are

directed posteriorly curving inward, extending as far as the anal ring, to which they are usually attached by the surrounding membrane. These processes present the only constant specific differences, in *mendosus* they are heavier and broader than in *fraternus*, but not as long. From a side view the processes in *mendosus* make an abrupt bend dorsally at about the middle, while in *fraternus* they curve or slope gradually. The styles of these two species are different from the other species of the subgenus, but they are very similar to each other. A considerable amount of variation especially in regard to the width and curvature of the terminal processes and their apices was found among the specimens of these two species examined. In *mendosus* the styles extend beyond the plates.

A pair of structures are present in each of these two species which have not been found elsewhere in the group. They are long tapering, flapper-like structures appearing netted and attached to the posterior part of the pygofer near the median line. From this point of attachment the free end extends anteriorly more than half the length of the pygofer. Occasionally they are found extending posteriorly outside the genital chamber. The external characters of the plates which might be used to separate these species have already been mentioned previously by the senior author. After studying a number of specimens of *mendosus* and *fraternus*, the only constant internal structures found are the oedagi, which are similar except for the bifurcate structures. The processes of these seem to be constant specific characters at least for the material studied.

These two species or species in the making should probably be given generic or subgeneric ranking, since internal and external structures both would indicate a rather distinct type of insect. They are therefore referred to a separate group as indicated here.

Genus *Latalus* nov.

(Plates II and III).

Vertex angularly produced, but usually not greatly longer than width between eyes. Reflexed arcs of front not visible from above. Elytra with short veinlets meeting costa at about right angles but differs from *Flexamius* in having no reflexed veinlets to costa. Elytra usually short just covering abdomen. Type of genus *sayi*.

The senior author has mentioned previously that this group is quite different from the species of *Flexamius* and it has seemed advisable to separate it because of further evidence obtained during this study.

Four species of this group are found in sufficient numbers so that specimens were obtained for a study of internal characters.

In external structures and general appearance *misellus*, *ocellaris* and *sayi* appear very closely related externally. The plates, pygofers and valves would indicate close relationship. An examination of the internal characters shows a great difference in structures. The oedagus is quite variable. In *misellus* the oedagus in ventral view appears very short, but a lateral view shows it to be long but directed dorsally and anteriorly. A pair of spine-like structures are found near the base of the terminal portion, while the dorsal portion is pointed. There are no anterior dorsal processes. The oedagus of *sayi* is very broad at the base, with two short lateral dorsal processes. The central portion is constricted and the terminal portion again broadened into two wing-like structures from between which a pair of long slender processes arise extending ventrally and anteriorly. In *ocellaris* the oedagus is comparatively narrow, the base being expanded and triangular in shape. Four terminal processes are visible, two of these are long and slender, directed anteriorly, two others are short and hair-like, directed posteriorly. The dorsal process of the oedagus seems most closely related to *sayi*.

Configuratus is apparently related to the *sayi-ocellaris* group, the oedagus being of the same general type. The oedagus of *configuratus* is broad at the base and the terminal one-fifth is split. In lateral view it shows similarity in its makeup to these other species. The styles are similar to *ocellaris* and *sayi*.

Genus **Polyamius** De Long.

(Plates IV and IX).

This subgenus was also erected by using primarily a wing character in the form of the cross veins of the clavus, as an important character. In this group we find a great similarity of external genitalia. The group thus seems to contain species

rather closely related to each other if we may judge from the similarity of internal genital characters as well as the external structures, and if the species examined are typical of the remaining unexamined and unavailable species.

The styles of the species throughout the group show great similarity, although specific in practically all of the species. The general shape and form, however, is very similar except in regard to minor details. In *obtectus* for instance the styles have very long anterior inner processes. In species like *arundineus* and *apicatus* these are of average length, while in species like *inimicus* and *texanus* these processes are very short.

The oedagus displays characters which are more varied and characteristic for the species of this group. What might be designated as a generalized type is represented by four of the species which were examined, namely, *apicatus*, *compactus*, *caperatus*, and *interruptus*. These four species have oedagi which are very similar. From a ventral view the oedagus in each of these species is enlarged at the middle, tapering anteriorly rather rapidly to an apex which is bluntly rounded, and posteriorly rather gradually to a bluntly pointed apex. In lateral view in each case the oedagus is enlarged in the central half and bears an anterior dorsal process extending slightly posteriorly and connected with the anal ring by a membranous structure. The posterior end of the oedagus is narrowed and curves dorsally. There is a specific difference shown in this character as the size and comparative length of this portion is characteristic for each species examined. *Caperatus* and *interruptus* exhibit the longer terminal portions, while *apicatus* and *compactus* display the shorter terminal processes.

From this generalized type the other species examined might easily have developed but along diverse lines. *Obtectus* for instance, which resembles *compactus* so closely in external appearance, might easily have developed from this type. In lateral view the oedagus is strikingly similar, but is tapered more gradually to the posterior end. In ventral view the oedagus is seen to be broader and more broadly rounded posteriorly, bearing a U-shaped notch at the apex.

The *weedi*, *texanus*, *micarius* group might also have arisen from a generalized form of this kind and since they resemble *interruptus* very strongly superficially this probably indicates the source or stem of such a development. The oedagus of

weedi in ventral view is not greatly different from *interruplus* except that it shows a bifurcate condition at the apex. In lateral view it is similar in that the terminal portion is narrowed, curved dorsally and even curves anteriorly in this particular case. It is quite different, however, since there is no anterior dorsal process, and since it is provided with an additional ventral posterior portion formed by the apparent division of the posterior half.

Texanus resembles *weedi* so closely in regard to color, size and form that they cannot be separated without examining the external genital characters. Upon examining the internal structures we find *texanus* is unique among these species especially in regard to the oedagus. From a ventral view the oedagus appears broader for a longer distance from the base, then narrows abruptly to a slender bifurcate apex. In a lateral view the oedagus appears entirely different from *weedi* but has the same number of parts which differ proportionately. The dorsal process is short and straight, flattened above. The ventral portion is longer and heavier, bent at right angles and extending dorsally with a bifurcate apex.

Micarius may have arisen independently of these two species, but it shows some similarity both externally and internally. The oedagus is not enlarged at the middle laterally, but is of about a uniform size and is slightly constricted near the apex. At the base is a short dorsal process and on the connective is found a pair of short dorsal spines. From a ventral view the oedagus is broad, slightly wider at the middle with a pair of teeth-like structures, one either side of a central rounded notch. *Micarius* apparently has come from this generalized type and is still very close to it in many respects.

The most common species of the genus *inimicus*, is very similar in the structure of the internal genitalia to the four species mentioned first. The oedagus in ventral view is long and broad with a broadly rounded apex. In lateral view it is broad at the base with a rather long dorsal process extending slightly anteriorly. The posterior half of the oedagus is narrowed, curved upward and terminates in a rather pointed apex.

Another species, *montanus*, described elsewhere as new, is known only from Montana and superficially resembles *inimicus* very closely. The internal genitalia also show similarity.

The styles are decidedly longer and more narrowed, with a different apex as shown by the figures, Plate IX. The lateral view of the oedagus also shows distinct differences. In *montanus* the oedagus is longer and more narrowed than *inimicus* and although similar as regards the general structure, it is distinct. The apical portion of the pygofer also is entirely different in the two species.

Arundineus shows more divergence than any of the other species, but the oedagus in lateral view shows some similarity to the generalized form. The dorsal process is present and in addition there are two dorso-lateral processes which extend posteriorly. The body of the oedagus gradually narrows to a slender pointed apex. In ventral view the oedagus appears somewhat complicated and confused. The body is broad at the base, but rapidly narrows, then slightly enlarges again just before the bifurcate apex. The dorsal process is broad and blunt at the apex. The dorso-lateral processes arise not far from the base and extend posteriorly, curving inwardly. The tips are pointed and each one is notched on the outer edge, giving it a barbed appearance.

Genus *Hebecephalus* De Long.

(Plates VI and VIII).

A head character was used as a basis for establishing this group. The vertex is usually bluntly angled and the front margin of the vertex is usually quite thick and bluntly angled with the front. The internal male characters indicate a rather close relationship of the species examined.

Three species have been available in sufficient numbers for an examination of the internal male structures. The styles are of the same general type although quite diverse specifically. In *signatifrons* there is a very deep indented portion near the tip forming a rather narrow sharply curved terminal portion. *Vinculatus* is definitely constricted at about half its length and is slightly indented at the tip. The apex is turned backward, prolonged, tapered and sharply angled. *Cruciatus* is only slightly curved at the apex because of a broad shallow notch. The oedagi are quite different in form also. In lateral view the oedagi of *vinculatus* and *cruciatus* are more similar, but in ventral view *vinculatus* shows more similarity to *signatifrons*.

In lateral view the oedagus of *cruciatus* is enlarged at the base, while *vinculatus* is scarcely larger in size basally. Both of these species have a basal spur directed dorsally and apically. In *signatifrons* the basal spur is directed dorsally and slightly anteriorly. The apical portion is longer than in either of the other species and is armed with two reflex spine-like structures at the tip which are quite long. In ventral view the oedagus of *signatifrons* is narrowed medially and the apical lateral spine-like processes are very conspicuous. The dorsal processes are conspicuous at the sides of the oedagus at the base. *Vinculatus* differs from *signatifrons* in having the lateral terminal processes much shorter and the oedagus not greatly widened at the base. *Cruciatus*, although widened at the base, does not bear lateral processes.

These characters are good specifically and yet tend to show a rather close relationship between these species examined.

Genus **Laevicephalus** De Long.

(Plates V, VI and VIII).

This group was established on the basis of a vertex which is angularly produced and with a flat discal portion. The vertex may be sharply, acutely or rather bluntly angled. This group is closely related to the species of *Thamnotettix* of the *inornatus* group and the wing venation is quite similar to the species of that group except for the two cross veins in the discal portion.

This genus contains a number of species which are very similar in appearance and with external genital characters quite similar in many instances although these external characters are usually specific and sufficient in most cases to separate them. There is a decided absence of color markings throughout this group. In view of these facts it is frequently considered that certain of these species are more closely related to each other than seems to be indicated by an examination of the internal genital structures. The type of head and other similar external structures are usually good characters to show relationships also.

When we examine the internal male structures we find on first examination what appears to be quite diverse structures, but after making a thorough study of these it is evident that certain relationships exist among these species.

An examination of the styles shows a great variation as represented by the different species. Most of these species have styles which might be placed in one of two general classes. The first group might be designated as a type with the terminal end usually squarely cut and blunt. The species of the second group have the terminal ends pointed and frequently an incised or indented portion which helps to form the terminal curved spur.

In the first group *acus* and *sylvestris* show close relationship having styles that are very similar. The base of each is broad and the terminal portion narrowed. Others of this group which show this character are *melsheimeri*, *debilis*, *spicatus*, *collinus*, *cincrosus* and *unicoloratus*. *Melsheimeri* and *debilis* have very similar styles with a constricted portion just before the blunt apex. *Unicoloratus*, although narrow at the base, is not greatly different from *acus* and *sylvestris*. *Spicatus*, *collinus* and *cincrosus*, although appearing similar because of their narrow basal portions, are each quite different from the others and unique when studied in detail. *Cincrosus* is slightly constricted near the apex and the basal portion is greatly curved and thus folded, which causes it to appear narrow. *Collinus* is broadened at the base and the basal portion appears the most narrowed because of the curved condition.

In the second group there is a great variation in the type of styles, especially in regard to indentation or constriction near the apex. *Striatus* is only slightly constricted near the apex, but the inner basal angle is greatly produced into a long narrow process extending to the connectives. *Abdominalis* has a style which is long and narrow and tapered to a pointed apex. The basal portion is tapered off on one side, but is prolonged on the other and folded back upon itself in such a way as to appear broad. *Auratus* is rather unique also since it is broad basally and apically and is constricted at the middle. The apical portion is pointed and is broadly curved to another pointed lateral portion. Another species which has a unique style is *littoralis*. It is as broad as long and the apical portion is abruptly narrowed to form a pointed apex. The outer basal portion is broad and greatly produced laterally. The generalized type of style is found in the case of *cicatrix*, *orbiculus*, *bimaculatus*, *subrutilus*, and *flavovirens*. *Cicatrix* and *orbiculus* show the rather deep indented apical portion with a curved,

sharply pointed apex. The basal portion is broad and the central portion constricted. *Subrutilus* and *bimaculatus* show a less indented condition near the apex. The broad basal condition is found in *subrutilus*, but in *bimaculatus* the basal portion is narrowed and rather pointed. The style of *parvulus* is gradually narrowed apically and is not indented. *Pascuellus* is of the same general type as regards the style, although only slightly indented apically and bluntly pointed.

These structures present good specific characters for the separation of these species in practically every case as contrasted with those subgenera where the styles are almost identical. These structures are therefore valuable for evidence of specificity and for the separation of species which are superficially so similar that they have been confused for many years.

The oedagi are even more diverse in character and more valuable in showing relationships and in forming evidence for specificity. If one should glance at the oedagi of these species as shown in either lateral or ventral view, he probably would see very little similarity between different species represented in this subgenus. A careful study of these species, however, shows rather definite similarities in structure.

The most simple type of oedagus and probably the most generalized type is found in *spicatus* and *debilis*. The latter species shows a small dorsal spur-like structure at the basal end, which character is quite common to the species of this genus. This structure is absent in *spicatus*. With slight modification it is easy to note the similarity between this type of oedagus and the type we see represented in a number of closely related species such as *orbiculus*, *subrutilus*, *melshemeri*, *parvulus*, *acus*, *sylvestris*, *unicoloratus* and *littoralis*. If we compare these in lateral view, Plate VIII, it is easy to make a relative comparison of these oedagi. *Orbiculus* and *subrutilus* are very similar to *debilis*, except that the dorsal spur is rather long in both cases and a pair of long lateral processes are found at the end of the apical portion of the oedagus in *subrutilus*, *melshemeri* and *parvulus* show further modifications. *Melshemeri* possesses a broad basal portion and the apical structure is rather long and slender. In *parvulus* the basal portion is missing and the dorsal process is much longer and directed apically. *Acus* and *sylvestris* are very closely related to each other and both show a further development of the oedagus especially in

length. The oedagus is extremely long and narrow, somewhat bent and slightly hooked at the apex. The most pronounced difference in the character of the oedagus in these two species is the distinctly longer dorsal spur in the case of *sylvestris*. *Unicoloratus* is not greatly different from *acus* and *sylvestris* and shows a rather close relationship to these species. The oedagus has a short spur at the base and a minute spine on the ventral side not far from the apex. The oedagus of *littoralis* is shorter and broader with a rather large spur extending dorsally.

Another group of three species, although distinct and differing considerably from each other, show a further development in the oedagus. Each of these has a pair or more of terminal processes and the oedagus in each case is strongly curved or looped basally so that the terminal portion of the oedagus extends almost dorsally. In *abdominalis* the oedagus is not enlarged and both basally and apically extends strongly dorsally with a pair of distinct apical processes. *Cicatrix* is enlarged basally with a short anterior dorsal process and a long apical dorsal process. The latter is set with two proximal pairs of anterior apical spine-like processes. If *flavovirens* is a "*Deltocephalus*" it probably is most closely related to this group. The oedagus of this species is somewhat similar to the former two. It is also enlarged basally and has a pair of terminal processes. There is some question too regarding the relative position of *bimaculatus*, which may not belong to this subgenus. The oedagus does not show strong similarity to any other of these species, but is probably most closely related to forms like *debilis* and *cicatrix*. *Collinus* and *cinerosus* are two species which have oedagi of a different type. They are similar only in view of the fact that they each have an oedagus with a pair of short basal processes and with a pair of terminal processes. They probably are not closely related. *Collinus* has an enlarged basal portion with a dorsal process, a pair of short lateral processes are found at the apex. In *cinerosus* the basal portion is not enlarged, but is directed dorsally then curves and extends apically and possesses a pair of rather long lateral processes near the apex which are directed backwards.

Two other species, *striatus* and *pascuellus*, have oedagi which are different from any others of the group. In *striatus* the oedagus seems to be turned upside down in lateral view with an anterior process extending ventrally in this case and the

oedagus is directed anteriorly and curves ventrally. In ventral view it is short and very broad. *Pascuellus* has an oedagus which curves back upon itself so that the apical half extends anteriorly. The most unique oedagus of the group is probably found in *auratus*. In this case the oedagus has a central portion with the dorsal terminal part enlarged. From the base a pair of long curved processes extend, on either side, past the apex of the terminal process of the central portion. Although superficially this species resembles *subrutilus* very closely and they have been placed under the same name for many years, there is no similarity of the structures of their oedagi.

The style-oedagus connectives show very good characters also, but it is not necessary to go into a detailed discussion of these. It might be advisable to simply point out the more important types and differences. Certain forms like *bimaculatus*, *parvulus*, *unicoloratus* and *collinus* have very short connectives. On the other hand species like *striatus* and *debilis* may have very long connectives. A comparison of the ventral view of these structures as seen in Plate VIII, will give a good idea of their variation among the different species.

Genus *Amplicephalus* De Long.

(Plates VII and VIII)

This genus was established chiefly upon the basis of the broad head character and three species have been placed in the genus to date. Two of these, *osborni* and *simplex*, have been available in sufficient numbers for dissection and a study of the genitalia. One of these, *osborni*, is a member of the freshwater marsh association, and the other, *simplex*, lives in the salt marsh association upon *Spartina patens*. The styles of these two species differ considerably. In *simplex* the style is broadest at the base and tapers to the apex, while in *osborni* the broadest portion is at the middle and the apical portion is comparatively longer. The oedagi are quite similar especially in lateral view, where the chief differences seem to be the shape of the terminal portion and the position and direction of the basal dorsal spur. In dorsal view the oedagus of *simplex* is much longer and tapered to a bifurcate tip. In *osborni* the tip is not greatly narrowed and a rather deep concavity is between the outer apices.

This group shows some similarity to both *Laevicephalus* and *Deltocephalus* species and is apparently closely related to certain groups now included in the genus *Euscelis*.

Genus **Deltocephalus** Burmeister.

(Plates VII and VIII).

In view of the fact that *pulicarius* was formerly chosen as the type of the genus it has been necessary to give this group the name of the original genus. This type was chosen by Oshanin and not by Van Duzee, as previously stated by the senior author. The vertex is short, bluntly angled and with disc sloping or convexly rounding from pronotum to the front. Margin of vertex usually very thick. The head character is again the one upon which emphasis was placed in establishing the group. The external genitalia are very similar, however, in the species throughout this group.

The examination of the external structures of the species of this subgenus would lead one to believe that these species are very closely related. In fact in a few cases there has been some question as to the specificity of certain forms. An examination of the internal genitalia has led to the same general conclusion, namely, that these species are a group of very closely related forms, although the internal characters indicate sufficient differences in structure to separate them quite easily.

An examination and study of the styles shows two rather distinct types to which most of the species belong. In one of these groups we might place *balli*, *minutus*, *vanduzei*, *pulicarius* and *castoreus*. These all contain relatively long sharp pointed terminal processes, although their relative width, the angular incision at the base of this process and the basal processes differ considerably. Of this group *pulicarius* and *castoreus* are quite similar, both lacking the deep curvature on the basal portion and the long pieces which articulate with the connectives; *balli* and *vanduzei* are of this later type. *Minutus* presents a somewhat different type with no indication of an articulation process, the basal portion curving from the outer lateral angle to the inner margin. *Flavicostatus* is quite similar to *minutus* in its general structure, but has a very peculiar and different process produced on its inner basal portion as an articulation process. One other species, *nigriventer*, possesses an extremely

long process and the shape of the style in general is entirely different from any other species that has been examined. A second group of species, including *nigrifrons*, *fuscinervosus*, *sonorus* and *marinus*, have rather short terminal processes. Otherwise they are somewhat variable especially in regard to slight differences in the basal structures. *Fuscinervosus* shows the greatest difference in the terminal process, since it is broader and more decidedly curved laterally. *Comesus*, a species described elsewhere, seems entirely different from these other species just considered and has a style which is gradually tapered to a blunt, rounded terminal portion.

An examination of the oedagi in side view shows that with the exception of two or three species the members of this subgenus are very similar in general type. This general type of oedagus is seen especially in *balli*, *pulicarius*, *comesus*, *sonorus*, *castoreus*, *vanduzeei*, *nigrifrons* and *fuscinervosus*. Each of these oedagi has an anterior dorsal process directed slightly caudally although the curvature or comparative length of the apical portion may vary slightly. A few species like *minutus* and *nigriventer* have this process directed almost anteriorly. *Nigriventer* presents other differences also in the body of the oedagus especially the anterior ventral portion. The oedagus of *marinus* has the anterior dorsal process, but the body of the oedagus is broad and heavy, appearing inflated and does not have the apical dorsally curved portion characteristic of these other species. *Flavicostatus* is also somewhat different, although it undoubtedly shows its relationship to this group. The apical portion of the oedagus is proportionately heavier, longer and directed more decidedly dorsally and slightly anteriorly. Specimens examined from various portions of South, Central, and North America would indicate that the North American forms, especially north of Mexico, are probably different as Mr. Van Duzee previously suggested and should be properly called *flavicosta*. The oedagus, as the accompanying figures, Plate VIII, will indicate, is more narrowed than, and is somewhat different in shape from *flavicostatus*.

In ventral view the oedagi show some specific and in a few cases unique, differences. *Marinus*, in view of the deeply cleft broad terminal portion, is entirely different from all the others. Species like *balli*, *nigrifrons*, *vanduzeei*, *fuscinervosus*, *pulicarius*, *sonorus*, *minutus*, *castoreus* and *comesus* have oedagi

that are quite similar in ventral view. But the comparative length or widened portions of these structures are apparently specific as in the case of *balli*, for instance, which is decidedly widened a little from the base, or *nigrifrons*, which is decidedly longer, as well as forms like *fuscinervosus* and *comesus*, which are apically enlarged or have apical processes. *Nigriventer* with its basal processes and pointed apex and *flavicostatus* with its broad rounded base and tapered apex are easily distinguished from the other species. In this group the connectives present a group of good characters also. Those of *flavicostatus* are unique, also different types are found in each of such species as *minutus*, *nigriventer*, *marinus* and *vanduzeei*.

There seems to be no question concerning the relationship between this group and certain species which have been included in the genus *Thamnotettix*. *Th. nigrifrons* and closely related forms have presented for some time a question upon generic status concerning which authorities have disagreed. The wing venation character upon which these were separated into different genera apparently must be superceded by the genital character in such cases which is apparently a better index to relationship. With *pulicarius* as the type of the genus *Deltocephalus* there is only one disposition to make in the case of *nigrifrons* and that is to place it in the same genus because of its great similarity.

The following new species have been described during this study:

***Flexamius surculus* n. sp.**

(Plates I and III).

Resembling *abbreviatus* very closely in form and appearance but with internal genitalia of the male and external genitalia of both sexes distinct. Length 3-3½ mm.

Vertex bluntly angled, almost one third longer at middle than width between eyes. Elytra short, scarcely covering abdomen.

Color: Very similar to *abbreviatus* and other closely related forms. Vertex with the dark brown circular mark around apex, the lines above margin of vertex, the transverse dashes on the disc and the longitudinal markings at the base present. Elytra varying in intensity of color but usually with a spot along outer claval vein, basal portion of the discal cell and a large spot on outer apical cell dark brown. Infuscation of veins on apical portion of elytra rather heavy.

Genitalia: Female last ventral segment with the posterior margin produced to form an angular lobe either side of the central two-thirds

which is rather deeply emarginate either side of a slightly produced central portion, heavily embrowned and composed of four teeth, two outer teeth sharp, narrow and more produced than the inner pair which are broader and more bluntly rounded. The outer teeth are separated from the inner pair by rather deep rounded notches. The inner pair are separated from each other by a rather broad V-shaped notch. Male valve broad, triangular. Plates exceeding valve by about its length, gradually tapering to about two-thirds their length where they are abruptly emarginate and narrowed to form the apical portions which are blunt and rounded to their inner margins. Pygophers greatly exceeding plates.

Described from a series of thirty-three specimens collected at Brownsville, Texas, by Prof. Herbert Osborn, in 1909, and now in his collection. These have been considered as variable specimens of *abbreviatus* until the present study has revealed them as a distinct species by means of the unique internal genitalia.

***Latalus ocellaris* var. *sobrinus* n. var.**

Resembling *ocellaris* in form and appearance but more robust, broader and with different female segment. Length $3\frac{1}{2}$ –4 mm. Vertex about as long as width between eyes, bluntly angled. Elytra short and broad.

Color: Similar to *ocellaris* but more conspicuously marked. The pair of triangular spots near apex of vertex and the larger areas just back of these dark brown. Pronotum dark with five pale longitudinal lines. Elytra conspicuously mottled with brown and white. Commissural line bordered with white, clavus with cells heavily infuscated on inner margins. Base of wing, discal cell and apical and antepical cells dark brown. Veins on central portion of wing broadly milk-white.

Genitalia: Female segment comparatively long, posterior margin gradually produced from lateral angles to form two short rounded teeth separated by a rounded or V-shaped notch. Posterior margin of segment black bordered. Male not known.

Described from six female specimens collected at Slave Lake, Alberta, Canada, August 14, 15 and 17, 1924, by O. Bryant, who forwarded these to the senior author. Other specimens have been examined from northern New York State.

Although *ocellaris* is reported for North America, all the specimens examined agree exactly with the above description and are different from European material at hand. European specimens of this species have a long produced tooth slightly bifurcate at the middle on the female segment. There are no intermediate forms and the North American type is described here and is in all probability a separate species.

***Polyamius aestuarium* n. sp.**

In general appearance resembling *arundineus* and allied species but the coloration of wings and face gives it the appearance of a species of *Scaphoideus*. Length 4 mm.

Vertex slightly wider between eyes than length at middle, flat or slightly depressed on disc. Pronotum slightly longer than vertex, more than twice as wide as long. Elytra exceeding abdomen, central anteapical cell constricted and divided, the anterior cell twice as long as posterior.

Color: Pale yellow, a pair of oblique orange bands extending from the margin of the vertex to the central posterior portion of the disc. Pronotum with a large orange spot along anterior margin extending between the eyes, and a large round spot on central portion of pronotum behind either eye. Basal angles of scutellum orange. Elytra orange yellow, veins milk-white and heavily infuscated at certain places. A large spot on the costal margin at about its middle, discal, central anteapical and apical cells fuscous. Face black above, extending obliquely beneath the eyes. Clypeus and lorae yellow.

Genitalia: Female last ventral segment rather short on lateral margins, then produced to form a broad trilobate posterior margin, only a slight notch is found either side of central lobe but the coloration causes it to appear decidedly trilobate. Lateral portions of underlying segment produced beyond last ventral segment at either side.

Described from a single female specimen taken at Carolina Beach, Wilmington, N. C., June 24, 1928, by the senior author. This was collected from the tidal salt marsh area and is so named.

The question of placing this species is somewhat in doubt, but it is placed in *Polyamius* because it resembles so closely species of this group and because the female genital segment is almost exactly like the majority of the species of this genus.

***Polyamius montanus*, n. sp.**

(Plates IV and IX).

Resembling *inimicus* in form and appearance but shorter with more bluntly angled head, slightly different coloration and genitalia distinct. Length $3\frac{1}{2}$ mm.

Vertex about one-fourth wider between eyes than length at middle. Pronotum slightly longer than vertex. Elytra shorter and broader than *inimicus* with anteapical cell constricted and divided. Claval area with only a few cross veins.

Color: Vertex with a pair of small round black spots just above apex and a pair of large round ones about half way between these and either eye. A pair of small round black spots on anterior margin of pronotum. Black spots on basal angles of scutellum showing through

the pronotum. Veins of elytra slightly infuscated. Reflexed arcs of face not seen from above on vertex.

Genitalia: Female last ventral segment rather short, side margins very short then gradually produced and rounded to posterior margin which is slightly indented either side of a central broad slightly produced tooth. Underlying membranes conspicuous beyond short lateral margins. Male valve broad and only slightly produced. Plates as broad as valve at base, gradually, concavely tapered to acutely pointed tips.

Described from a series of two female and ten male specimens collected July 12, 1927, by Dr. Walter Carter at Bozeman, Montana. Two males, one of which is designated as the type, are in the collection of the senior author. The others which have been examined in the National Museum collection are designated as paratypes. A series of specimens collected by Dr. Martha Shackelford, at Friday Harbor, Washington, during the summer of 1928, are undoubtedly the same species.

***Laevicephalus cicatrix*, n. sp.**

(Plates V and VIII).

Resembling *striatus* in form and appearance but with head slightly more angled and genitalia distinct. Length $3\frac{1}{2}$ –4 mm.

Vertex bluntly angled, a little wider between eyes than length at middle. Pronotum shorter than vertex, very short behind the eyes. Elytra slightly longer than abdomen, outer anteapical cell very short.

Color: In coloration resembling a well marked specimen of *striatus*. Face with nine pairs of brownish arcs, the ventral pairs paler. Vertex with a pair of converging curved lines extending from ocelli to either side of apex, and a median line extending two thirds of the way from base to apex, brown. Veins of elytra heavily infuscated. Ovipositor black or dark brown.

Genitalia: Female last ventral segment rather long, roundly produced from either side to central third which is rather abruptly roundly emarginate either side of a slightly produced central lobe which is slightly notched at center. Base of emargination either side, with a black spot. Male valve more than twice as broad as long, bluntly rounded. Plates about twice longer than valve, convexly rounded to rather broadly rounded apices. Male internal genitalia distinct as indicated.

Described from a series of eight female and seven male specimens collected at Slave Lake, Alberta, Canada, August 14 to 17, 1924, by Mr. O. Bryant and forwarded to the senior author for identification.

***Laevicephalus orbiculus*, n. sp.**

(Plates V and VIII).

Size and coloration of *debilis* and resembling it very much. Head more bluntly angled and genitalia distinct. Length $3\frac{1}{2}$ mm.

Vertex very bluntly angled, slightly wider between eyes than length at middle. Pronotum shorter than vertex and more than twice as wide as long, lateral margins very short. Elytra short and broad, flaring.

Color: Vertex, pronotum and scutellum straw yellow, slightly tinted with green, elytra dark green, veins yellowish. Ocelli black. Dorsal portion of abdomen mostly black.

Genitalia: Female last ventral segment rather long, lateral angles produced and prominent, between which the posterior margin is concavely rounded about one-third the distance to the base at the center of which a slight notch forms a pair of slightly produced rounded black teeth. Male valve rather broadly rounded. Male plates broad, gradually tapering to blunt rounded tips, a black spot about the middle of each plate. Pygofer scarcely longer than plates. Male internal genitalia distinct.

Described from thirteen female and eight male specimens collected at Mammoth Hot Springs, Wyoming, July 9, 1909, by Professor Herbert Osborn and now in his collection.

This species can best be separated from *debilis* by the male and female genital characters. The male of *debilis* has plates which are more convexly rounded and greatly exceeded by long pygofer. The female segment of that species does not have prominent angles on the last ventral segment.

***Laevicephalus subrutilus*, n. sp.**

(Plates V and VIII).

Resembling *auratus* in form and coloration, but more yellowish with vertex more produced and angled. Male plates more narrowed and produced, internal genitalia greatly different. Length 3 to $3\frac{1}{2}$ mm.

Vertex bluntly angled, as wide between eyes as length at middle and one-fourth longer than pronotum. Pronotum broad and very short at lateral margins. Elytra when of the brachypterous type exposing the last two dorsal segments. Usually this type of wing is present in the female specimens.

Color: A rather uniform orange yellow without definite markings. The toothed portion of the female segment is black margined. As contrasted with *auratus* it shows more yellow and less of the bright, distinct orange color.

Genitalia: Female last ventral segment rather long, lateral angles produced and broadly sloping to central excavated portion, at the

base of which is found a rather broad, produced tooth which is black margined and appears slightly incised at middle. Male valve bluntly angled, male plates rather long, gradually tapering to rounded apices. In *auratus*, with which this species has been confused, the plates are much broader and shorter.

Described from a series of six female and two male specimens all collected at Dickinson, N. D., by Prof. Herbert Osborn. Type in Osborn collection. This species has been confused for many years with *auratus*, which it resembles very much superficially. The shorter, blunt head character, the more orange coloration, the external and internal genital characters as described and figured will easily separate these two species.

***Deltocephalus comesus*, n. sp.**

(Plates VII and VIII).

Resembling *balli* in size and coloration, slightly more robust and with distinct male genitalia. Length 3-3½ mm.

Vertex broadly bluntly angled, almost rounded, slightly more than half as long on middle as width between the eyes. Pronotum longer than vertex and more than twice as broad as long. Elytra with middle anteapical cell constricted and divided.

Color varying from yellow to light brown with definite markings more or less distinct. Vertex with four black spots varying in size just above margin and a transverse dash either side behind the ocellus extending from eye almost to outer spot. Vertex pronotum and basal angles of scutellum more or less mottled with orange.

Genitalia: Female last ventral segment with prominent lateral angles, broadly angularly excavated halfway to base. Central third heavily embrowned. Male valve broadly convexly rounded, plates short, exceeding valve by about its length, gradually tapering to blunt broadly rounded apices. Male internal genital structures distinct as illustrated.

Described from five female and three male specimens from Brownsville, Texas, June 23, 1908, and one female specimen from Arizona. Type in collection of senior author.

EXPLANATION OF PLATES.

PLATE I.

Ventral and lateral view of internal genitalia in situ.
Genus *Flexamius*.

PLATE II.

Ventral and lateral view of internal genitalia in situ.
Genus *Alapus*, Genus *Lalulus* and Subgenus *Secopennis*.

PLATE III.

Comparative view of styles (top) and oedagi from ventral and lateral views of species of genera in Plates I and II

PLATE IV.

Ventral and lateral view of internal genitalia in situ.
Genus *Palus* and *Polyamius*.

PLATE V.

Ventral and lateral view of internal genitalia in situ.
Genus *Laevcephalus*.

PLATE VI.

Ventral and lateral view of internal genitalia in situ.
Genus *Laevcephalus* and *Hebecephalus* (lower right).

PLATE VII.

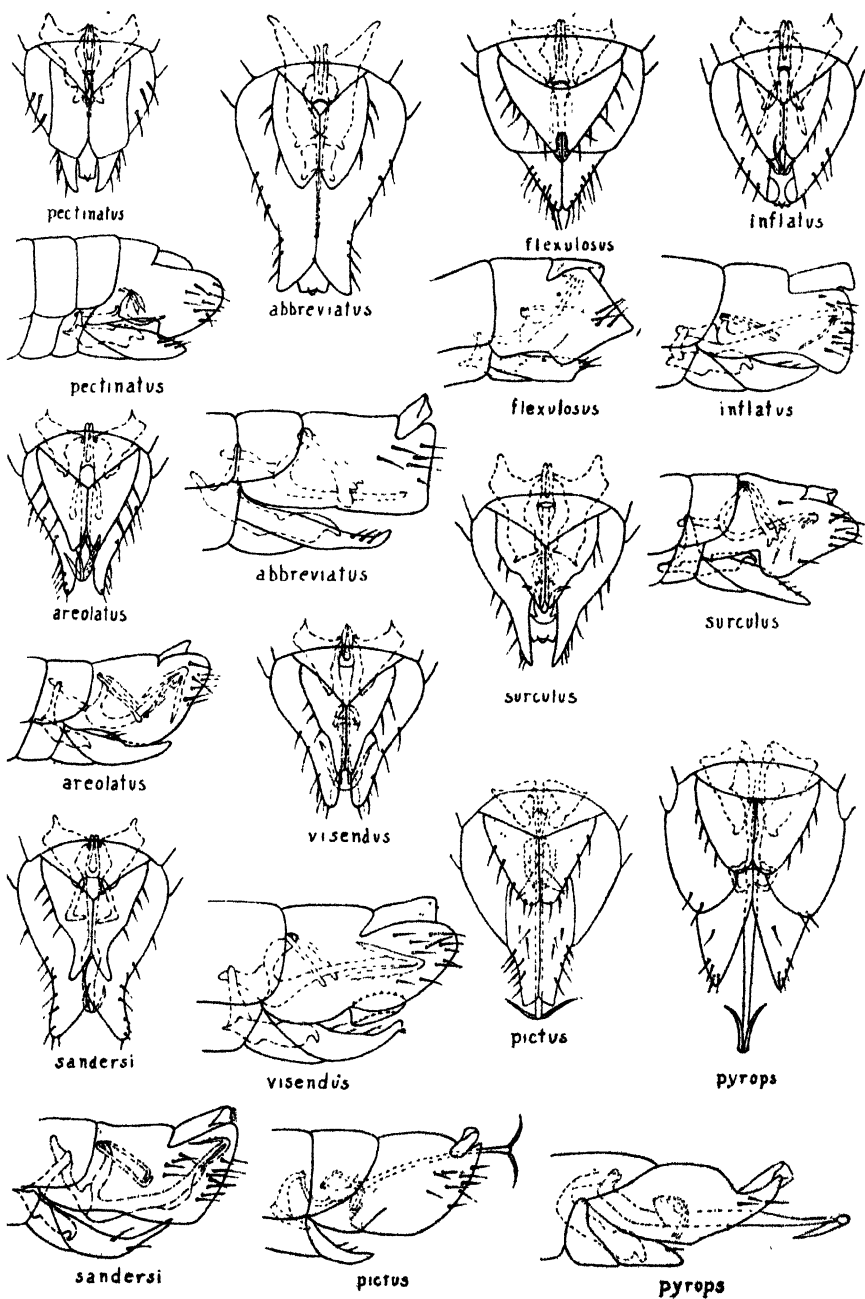
Ventral and lateral view of internal genitalia in situ.
Genus *Amplicephalus* (top) and *Deltocephalus*.

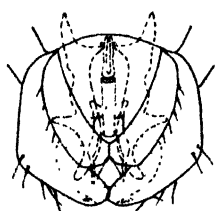
PLATE VIII.

Comparative view of oedagi, ventral aspect (top) and lateral (lower) of
Genera *Laevcephalus*, *Hebecephalus*, *Amplicephalus* and *Deltocephalus*.

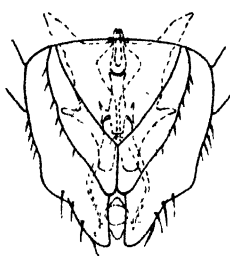
PLATE IX.

Comparative view of oedagi ventral and lateral aspects (top) and styles
(middle) of Genera *Palus* and *Polyamius*. Ventral view of styles
(lower) of Genera *Laevcephalus*, *Hebecephalus*,
Amplicephalus and *Deltocephalus*.

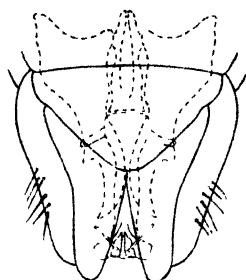




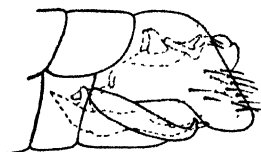
mendosus



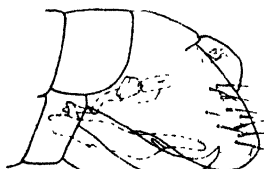
fraternus



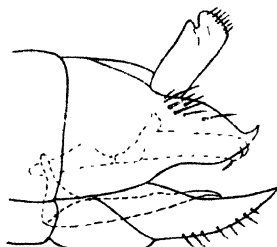
sayi



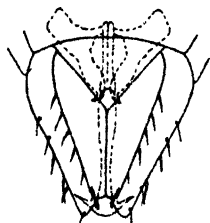
mendosus



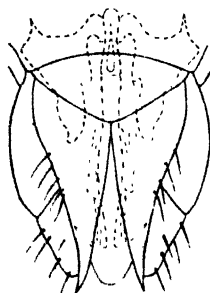
fraternus



sayi



albidus



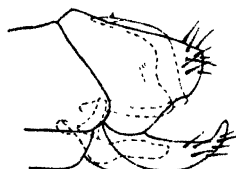
slosoni



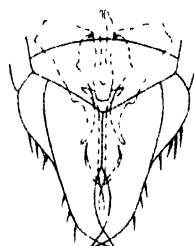
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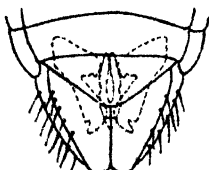
albidus



misellus



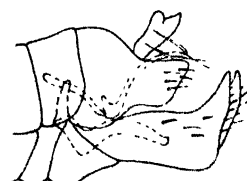
ocellaris



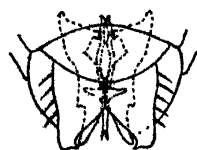
misellus



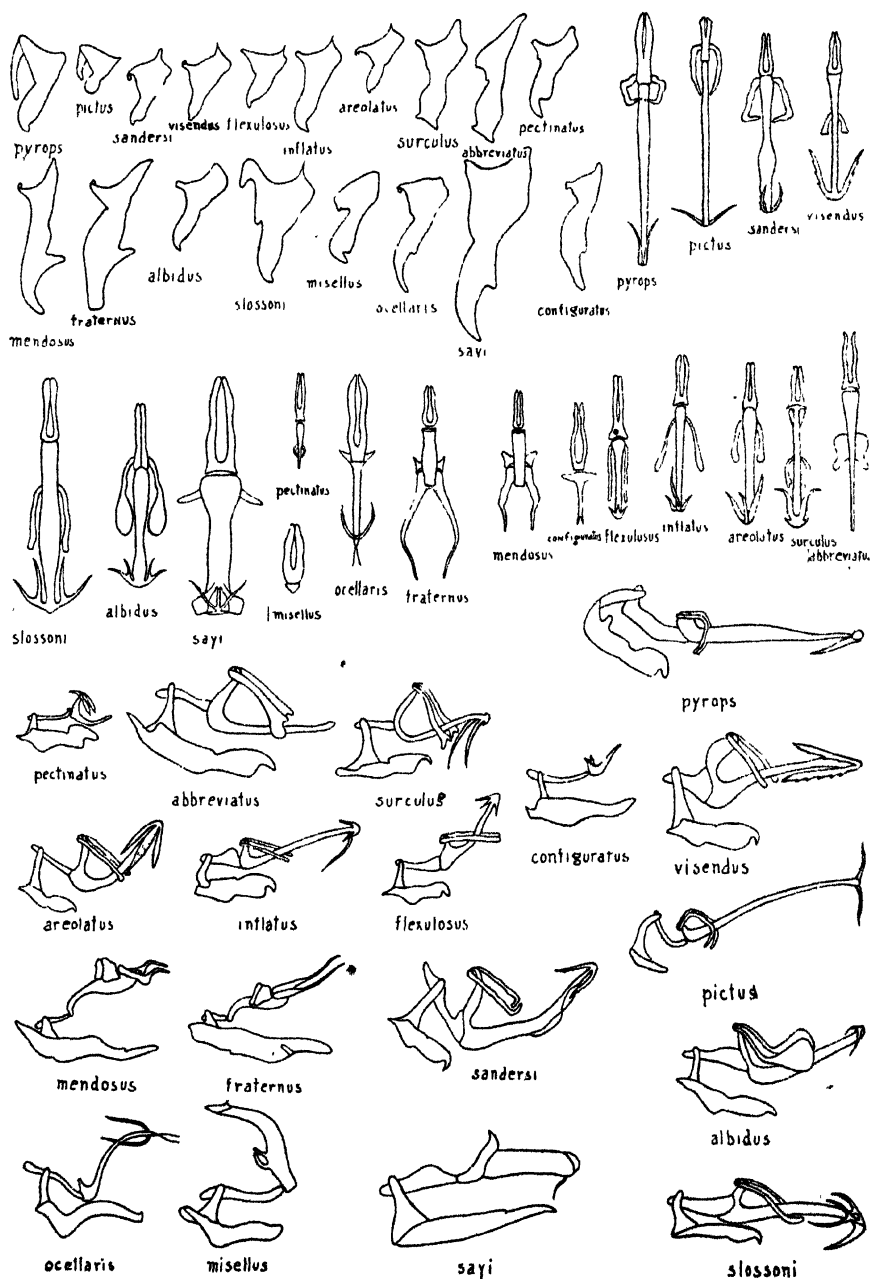
configuratus

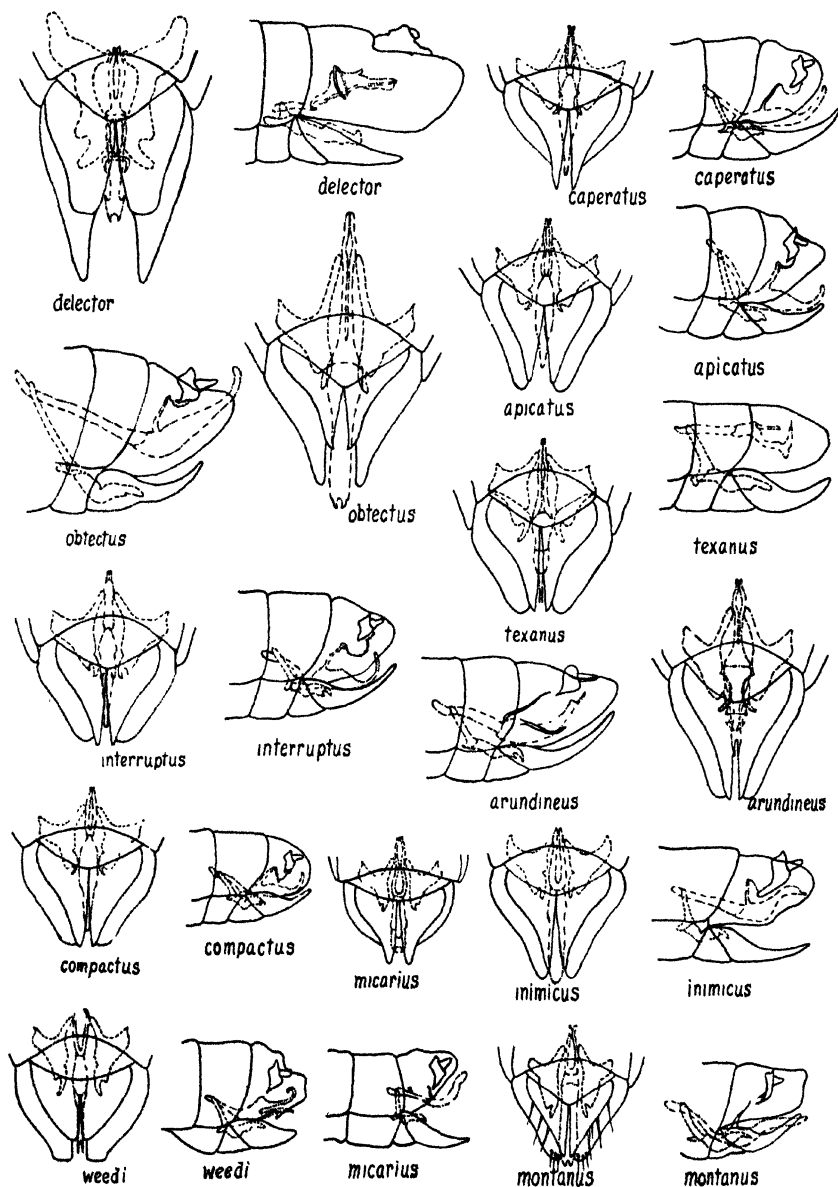


ocellaris



configuratus



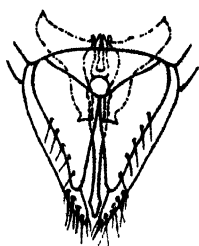




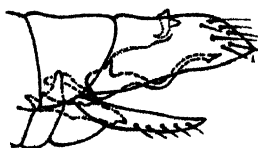
parvulus



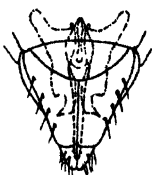
parvulus



acus



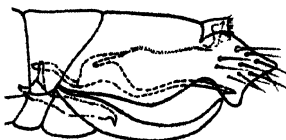
acus



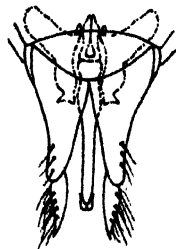
melsheimerii



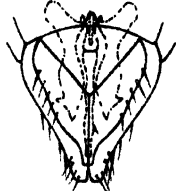
melsheimerii



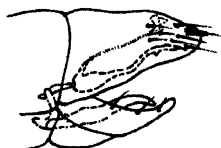
sylvestris



sylvestris



unicoloratus



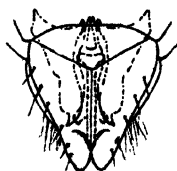
unicoloratus



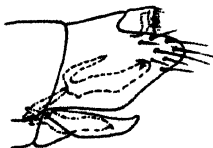
pascuellus



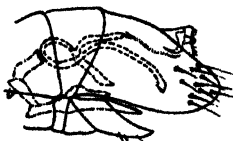
pascuellus



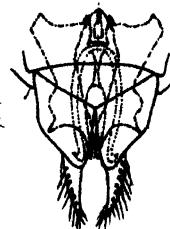
subrutilus



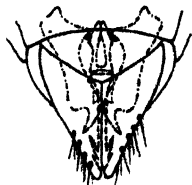
subrutilus



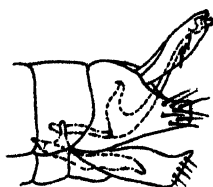
auratus



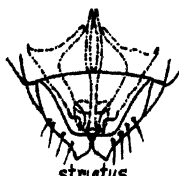
auratus



cicatrix



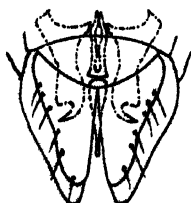
cicatrix



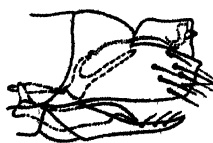
striatus



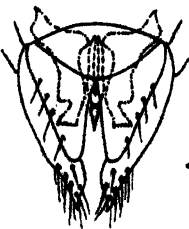
striatus



orbiculus



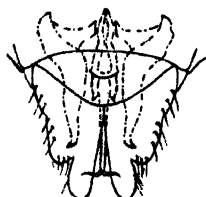
orbiculus



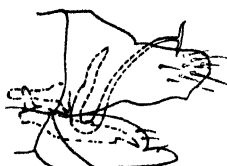
debilis



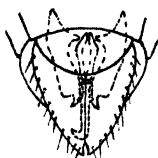
debilis



abdominalis



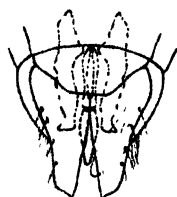
abdominalis



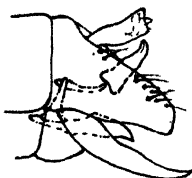
bimaculatus



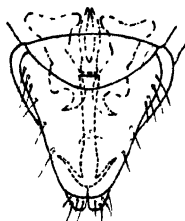
bimaculatus



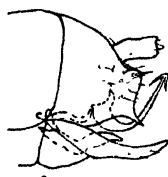
spicatus



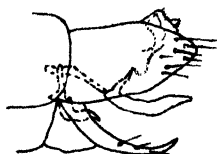
spicatus



flavovirens



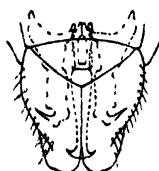
flavovirens



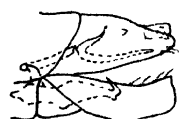
littoralis



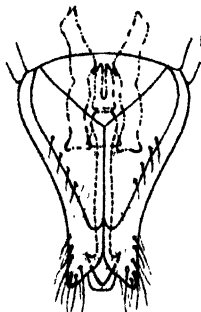
littoralis



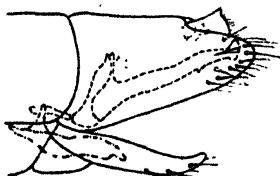
vinculatus



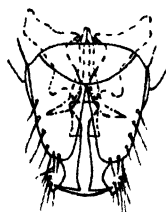
vinculatus



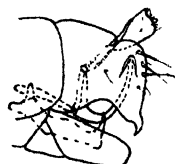
collinus



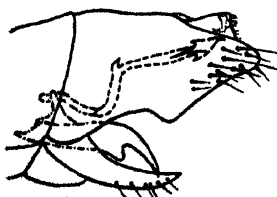
collinus



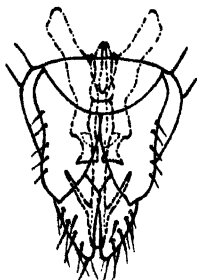
signatifrons



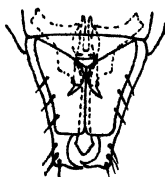
signatifrons



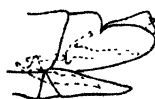
cinerosus



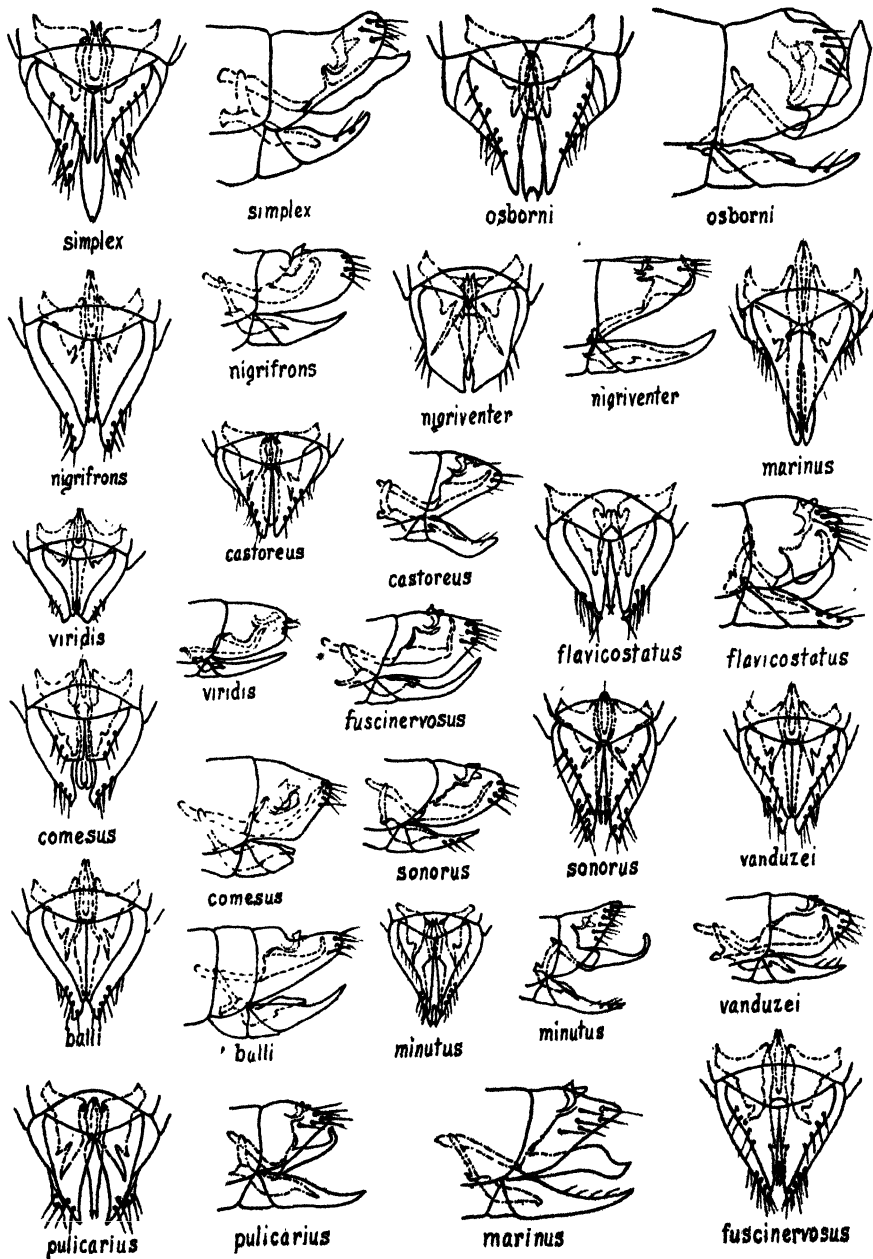
cinerosus

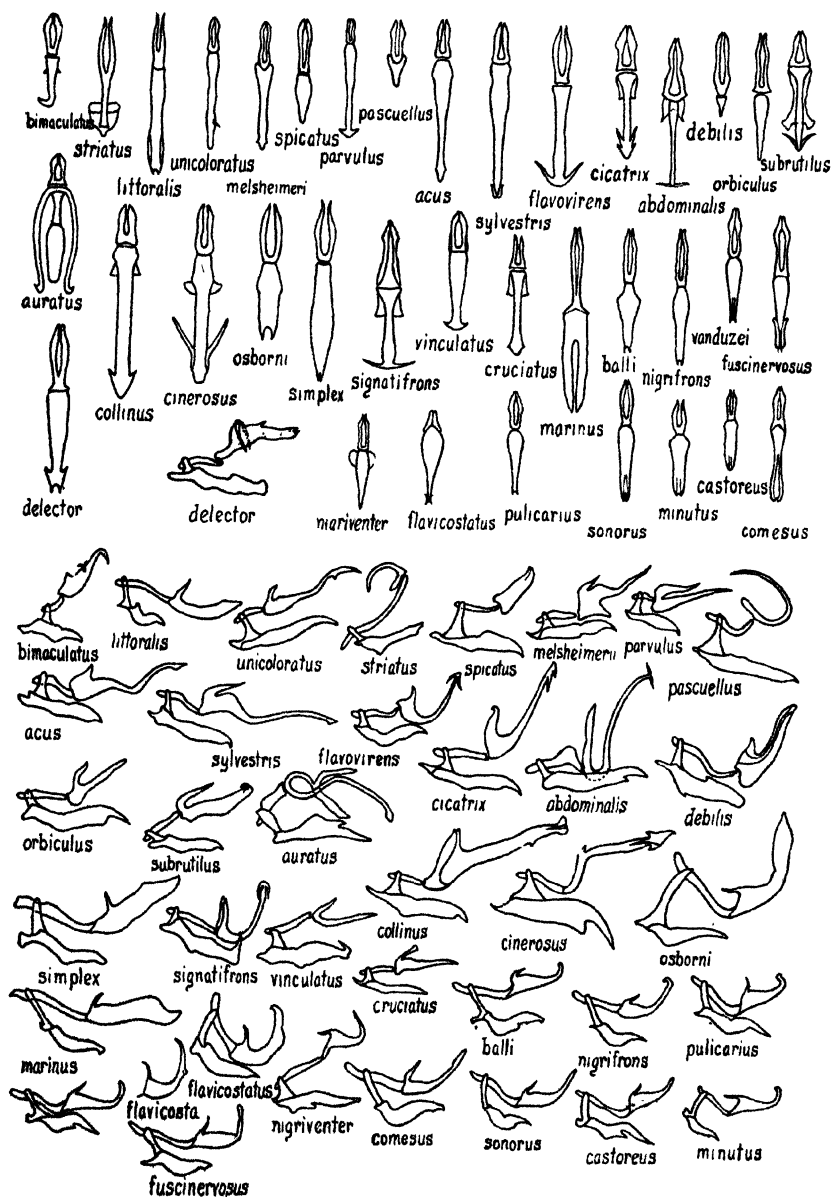


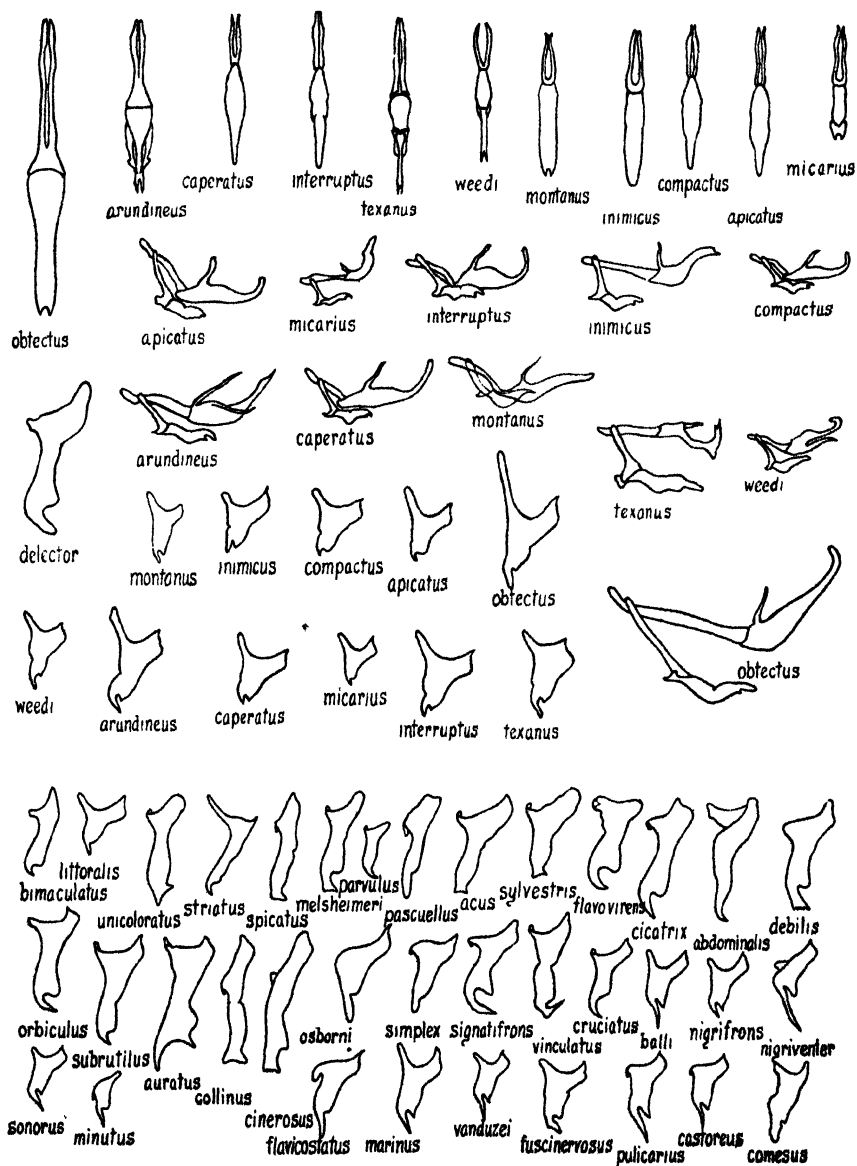
cruciatus



cruciatus







ERYTHRONEURA (HOMOPTERA, CICADELLIDÆ) FROM THE SOUTHWEST.*

R. H. BEAMER,
University of Kansas.

The Biological Survey Party from the Department of Entomology of the University of Kansas spent the summer of 1927 collecting in the southwest part of the United States. (Arizona, New Mexico and southwestern Texas). The objectives of the party were two fold: first, to make an intensive survey of the aquatic Hemiptera of this region; and second, to visit, as far as time would permit, the localities where Professor F. H. Snow had collected in former years. The trip was a very profitable one, yielding about 25,000 specimens, a number of which are new. The present paper deals with the species of *Erythroneura* collected in that region.

To a native of Kansas, accustomed to collecting *Erythroneura* by the thousands, their scarcity in this western region was disappointing. Wild grape vines and scrub oak in one or two localities produced specimens in numbers, but these were represented by a very few kinds. Most of the specimens were taken, a few here and a few there, by arduous work with the sweep net. The fact that twenty-three of the twenty-one species taken were new to science compensates somewhat for their lack in numbers.

Following the example of previous writers in this group the male genitalia were dissected and studied. Unlike them, however, they were mounted on slides and photographed rather than drawn, care being taken to get the various specimens in the same relative position.

Species were found which belonged to the various groups as established by W. L. McAtee and Wm. Robinson, as well as a number of species with two types of genitalia not hitherto mentioned. One of these is represented by one species which externally has characters between *Hymetta* and *Erythroneura*, although more like the latter. The male genitalia, (Plate II,

*Contribution from the Department of Entomology, University of Kansas, Lawrence, Kansas.

Fig. 19), could belong to the *Scutelleris* group of *Erythroneura* although they are totally unlike any known species. The other type of genitalia represented by eleven species, is characterized by the pygofer having two hooks or processes which come from different portions of the pygofer and project more or less toward each other, and by a sameness in the shape of the claspers. It could be argued that these two types of genitalia should be set off as generically distinct. The specimens of both groups, however, fall easily into the genus *Erythroneura* on external characters, so no need is seen for additional names.

The twenty-six species known to occur in this region, have been included in the key. Twenty-three of them were collected on this trip. Twenty-one of them are new to science. All types are deposited in the Snow Entomological Collection.

KEY TO THE SPECIES.

- A. With longitudinal oblique stripes on dorsum.
 - B. Vertex, pronotum and scutellum without definite markings.
 - C. Body light colored..... *pallentia*
 - CC. Body dark.
 - D. Large species, oblique markings, very light..... *obscura*
 - DD. Smaller species, oblique markings distinct..... *triceroprocta*
 - BB. Vertex, pronotum and scutellum with markings.
 - C. Vertex with dark markings.
 - D. Vertex with one dark spot..... *casta*
 - DD. Vertex with three or four dark spots..... *tripunctata*
 - CC. Vertex with faint oblique stripes, no dark spots.
 - D. Costal margin of tegmen without vitta..... *cimarroni*
 - DD. Costal margin with lemon-yellow vitta..... *pinalensis*
- AA. With markings otherwise.
 - B. Without markings..... *unicolor*
 - BB. With markings.
 - C. Markings in the form of cross-bands.
 - D. With five cross-bands..... *canyonensis*
 - DD. With seven cross-bands..... *nicholi*
 - CC. Markings otherwise.
 - D. M-Cu cross-vein absent, M_{3+4} and Cu forming a more or less continuous line.
 - E. Base of cell M_4 oblique, apex of cell R_5 without a black cloud or spot.
 - F. Both vertex and scutellum with two black dots..... *bipunctata*
 - FF. At least scutellum without black dots.
 - G. Markings usually red..... *carmini*
 - GG. Markings orange..... *texana*
 - EE. Base of cell M_4 square, apex of cell R_5 with a black spot or cloud.
 - F. Base of scutellum with two black spots..... *coloradensis*
 - FF. Base of scutellum without two black spots.
 - G. Apex of vertex with a black dot..... *aprica*
 - GG. Apex of vertex without a black dot.
 - H. Markings of pronotum usually U-shaped..... *ancora*
 - HH. Markings of pronotum usually Y-shaped.
 - I. Tegminal vittæ broad, fusco-rufous..... *anfracta*
 - II. Tegminal vittæ orange..... *gilensis*

DD. M-Cu cross-vein present.

E. Base of cell M_4 oblique, almost a straight line.

F. Tip of scutellum black. *kiperi*

FF. Tip of scutellum light.

G. Distinctly three-colored, face with a black band crossing it *tricolor*

GG. Markings orange, no band on face *milleri*

EE. Base of cell M_4 distinctly angled, not a straight oblique line.

F. Color markings consisting of scattered spots.

G. Black spots of tegmina almost circular. *illinoensis*

GG. At least one black spot on tegmina much elongated, *illinoensis* var. *regalis*

FF. Color markings almost solid.

G. Costal plaque with a red blotch.

H. Large, female 3.7 mm. *grandis*

HH. Smaller, female 2.7 mm. *rubicunda*

GG. Costal plaque without red blotch. *variabilis*

Erythroneura pallenta n. sp.

General ground color yellowish white. Vertex, pronotum and scutellum without markings. Tegmina with faint, yellow, parallel, oblique stripes, one near middle of clavus, another following cubitus and a third on costal margin from humeral angle to cross-veins, the latter about as wide as the costal plaque. Cubital vittæ decidedly narrower than the others. Tegmina, from cross-veins to apex, slightly fumose. Abdomen straw colored throughout.

Genitalia.—Pygofer with two large hooks. Oedagus quite long, ending in a triangle, without other processes. In this it differs from *cimarroni* n. sp. to which it seems to be related. (Pl. I, Fig. 6 and 6a).

Holotype, male; Oak Creek Canyon, Arizona, August 14, 1927; R. H. Beamer.

Erythroneura obscura n. sp.

General ground color yellowish white. Vertex, pronotum and scutellum without markings. Tegmina with very faint yellow lines through middle of clavi and along cubitus. Slightly smoky beyond cross-veins. Abdomen more or less darkened throughout.

Genitalia.—A heavy oedagus characterizes the genitalia. It ends in a triangular-shaped head. The tip curves up in lateral view, as do the two posterior angles. The pygofer has two hooks or spines, both of them pointing posteriorly. (Pl. I, Fig. 1 and 1a). This character would seem to relate this species more closely to *triceroprocta* n. sp. (Pl. I, Fig. 10 and 10a). than to the others with double pygofer hooks.

This species externally closely resembles *pallenta* n. sp. but may be distinguished from it by the dark abdomen, the much fainter lines on tegmina and by the male genitalia.

Holotype, male; Huachuca Mts. Ariz. August 1, 1927; R. H. Beamer.

***Erythroneura triceroprocta* n. sp.**

General ground color semi-hyaline to whitish. Vertex, pronotum and scutellum tinged with yellow, no definite markings. Tegmina with two narrow, oblique, parallel stripes. The first runs through middle of clavus and the second follows cubitus. In some specimens media and radius are tinged with yellow for a short distance before the cross-veins.

Genitalia.—Pygofer hooks, two, posterior one small and projecting posteriorly. Oedagus extremely large and heavy, flattened laterally and divided into three main divisions, the median one of which again divides into two processes which bend out near their middle at right angles, making a laterally-flattened, four-pronged, dorsally-curving, organ. (Pl. I, Fig. 10 and 10a).

This species externally looks much like *obscura* n. sp., but is smaller and the oblique markings are more distinct, while the male genitalia are nothing like any other named species.

Holotype, male; Culberson Co., Texas; July 7, 1927; R. H. Beamer. *Allotype*, female; eight female and four male paratypes, same data.

***Erythroneura casta* n. sp.**

General ground color yellowish white to hyaline. Apex of vertex with small circular black spot, from which in some specimens a dark narrow line extends to pronotum. A more nearly lemon yellow spot at base; two triangular orange spots near base of pronotum, separated by a rather broad whitish stripe. Middle two-thirds of clavi from base of tegmen to slightly beyond anterior end of costal plaque, orange. This continues to tip of clavi as lemon-yellow stripe. Corium marked with two lemon-yellow stripes, the outer as wide as costal plaque, extending from base of tegmen to the region of cross-veins; the inner of about same width as outer and beginning even with the anterior end of costal plaque, ending at the cross-veins. Tegmina from cross-veins to apex smoky.

Genitalia.—Pygofer hooks two in number. Oedagus, viewed dorsally, has two pairs of processes, one from base and one from apex, the ends of which diverge somewhat as they approach each other. (Pl. I, Figs. 8 and 8a).

Holotype, male; Huachuca Mts., Arizona, August 1, 1927; R. H. Beamer. *Allotype*, female; 38 female and 127 male paratypes, same data.

All specimens were swept from very short, scrubby oaks growing on the east side of Car Peak a short distance from the top.

Erythroneura tripunctata n. sp.

General ground color semi-hyaline except vertex, pronotum and scutellum, which are yellowish white. Vertex with three fuscous spots at apex, an indication of a median fuscous line at base. Pronotum with two indefinite yellow vittæ slightly diverging anteriorly and a smoky circular spot on each lateral margin. Some specimens have other smoky blotches. Scutellum with basal angles and extreme tip smoky. Tegmina hyaline except two faint, parallel, lemon-yellow vittæ, one near middle of clavi, the other near cubitus, and with slight fumosity from cross-veins to tip.

Genitalia.—Pygofer hooks double. Oedagus broad and heavy in lateral view, with a pair of heavy ventral processes. (Pl. I, Figs. 5 and 5a).

Holotype, male; Oak Creek Canyon, Arizona, August 14, 1927; R. H. Beamer. *Allotype*, female; three female and one male paratypes, same data. Five female and one male paratypes, Culberson Co., Texas, July 10, 1927; R. H. Beamer.

Erythroneura cimarroni n. sp.

General ground color pale yellowish white on vertex and pronotum; tegmina light, almost hyaline with oblique, parallel, lemon-yellow stripes. Vertex and pronotum in some specimens slightly tinged with oblique stripes; claval stripe narrow, in middle of clavus, parallel with claval suture. Corial stripe follows cubitus to cross veins. Media and radius often slightly yellowed.

Genitalia.—Pygofer hook double. Oedagus long, ending in triangular head with two backward projecting processes. (Pl. I, Figs. 7 and 7a).

Holotype, male; Colfax Co., New Mexico, August 21, 1927; R. H. Beamer. *Allotype*, female; two male and seven female paratypes, same data.

This species is apparently related to *pallenta* n. sp., according to the male genitalia. It differs from that species principally in the processes of the oedagus.

Erythroneura pinalensis n. sp.

General ground color semi-hyaline, except pronotum and vertex, which are pearly white. Vertex with median light stripe bordered by two curved, yellowish vittæ, which curve sharply outward anteriorly, ending in darkened area in one specimen, and which expand rapidly posteriorly. The same condition exists on pronotum, except that the yellow vittæ curve out posteriorly instead of expanding. Scutellum with basal triangles yellow and extreme tip fuscous. Tegmina hyaline, with three longitudinal lemon-yellow vittæ; first in center of clavi; second on cubitus; and third on costal margin including costal plaques.

Tip of clavi and tegmina, from slightly anterior to cross-veins, lightly fumose in some specimens.

Genitalia.—This species has the double pygofer hooks and a very peculiar *œdagus* with its seven upward projecting hooks. It does not resemble the *œdagus* of any of the other species. (Pl. I, Figs. 4 and 4a).

Holotype, male; Pinal Co., Arizona; August 6, 1927; R. H. Beamer. *Allotype*, female; one male paratype same data.

***Erythroneura unicolor* n. sp.**

General ground color white, slightly tinged with yellow. Practically no other markings. On the holotype there is a slight orange tinge for a short distance on the mesal margin of the clavi almost to the tip. The vertex, eyes and basal angles of scutellum tend to have a purplish cast. This species is practically concolorous.

Genitalia.—Genitalia very characteristic, with pygofer hooks double, the anterior one composed of two hooks, and the long heavy *œdagus* with its pair of anteriorly projecting processes coming out near its apex. (Pl. I, Fig. 9 and 9a).

Holotype, male; Culberson Co., Texas; July 10, 1927; R. H. Beamer. *Allotype*, female and three paratype females, same data.

***Erythroneura canyonensis* n. sp.**

Close to *nicholi* Beamer, although it has but five cross-bands while *nicholi* has seven.

General ground color pearly white, with cross-bands of darker color. Vertex yellowish white, fumose mesally. Pronotum fuscous, a small portion of anterior margin of same color as vertex. First cross-band, including most of pronotum, scutellum and bases of tegmina, reddish brown on tegmina and scutellum. Second band white, extending to middle of clavus. Third band ferrugineous, extending about to posterior edge of costal plaque. Fourth band white, extending almost to cross-veins, with a tendency to a broken ferrugineous line near its middle. Fifth band fuscous, occupying remainder of tegmina. Cross-veins whitish. Venter dark.

Genitalia.—Genitalia characterized by broad *œdagus*, from lateral view, tapering into a long slender tip. Basally a pair of rather heavy processes project parallel with the *œdagus* about one-third its length. These are much larger in this species than in *nicholi* Beamer. Pygofer has two hooks. (Pl. I, Figs. 2 and 2a).

Holotype, male; Grand Canyon, Arizona; August 11, 1927; R. H. Beamer. *Allotype*, female, and 27 male and 6 female paratypes, same data.

All the specimens were collected about 900 feet down from the rim of the Grand Canyon on Bright Angel trail.

***Erythroneura nicholi* Beamer.**

A photograph of the male genitalia is included to help separate it from *canyonensis* n. sp. No specimens of this species were taken. (Pl. I, Figs. 3 and 3a).

***Erythroneura bipunctata* (Gill).**

This species was not collected, but is included because it was described from this region.

***Erythroneura carmini* n. sp.**

General ground color milky white. Vertex usually with three dark red spots. Pronotum with a dark red spot in each anterior angle and a larger median one of varying size and shape, often a short heavy V. Scutellum with lateral angles usually margined with dark red and a large spot on tip of same color. Tegmina with the following bright red markings: clavus with anchor-shaped mark on anterior two-thirds, which usually does not touch the claval suture, the base of clavus nor the inner margin and a much smaller spot bordering the inner margin and near the tip; corium with oblique vitta beginning on costal margin near humeral angle and ending on claval suture, a zigzag vitta beginning in costal margin at anterior end of costal plaque touches the claval suture in two places ending on M_2 just short of the cross-veins. A black spot in posterior end of costal plaque and a larger one in base of cell M_4 . Apex of tegmen dusky. A bright red spot on mesosternum beneath base of wings.

Genitalia.—Pygofer hook composed of two almost equal processes, the inner heavier and slightly shorter. Oedagus moderately short and slightly bulbous. (Pl. II, Figs. 13 and 13a).

Holotype, male; Anderson Co., Kansas; September 9, 1927; R. H. Beamer. *Allotype*, female; Gila Co., Arizona; August 5, 1927; R. H. Beamer. *Paratypes*, 4 females and 4 males, Gila Co., Arizona; August 5, 1927; 1 female and 1 male, Oak Creek Canyon, Arizona, August 14, 1927; 7 males, Douglas Co., Kansas, 1926; 1 male, Cloud Co., Kansas, 1927; 7 males, Cherokee Co., Kansas; 2 males, Anderson Co., Kansas; 1 male, Colfax Co., New Mexico, August 21, 1927; R. H. Beamer.

***Erythroneura texana* n. sp.**

General ground color creamy white. Vertex with a median orange circle enclosing a white dot. Pronotum with a median U-shaped orange mark broadest near middle, not extending to either margin, and an orange spot in each anterior angle. Scutellum with an outline of a triangle in basal angle and tip orange. Tegmina with following orange markings: an oblique vitta enlarged caudally to face the tegminal

suture in basal half of clavus; spot near tip of clavus; an oblique vitta on corium near humeral angle; a continuous more or less irregular vitta bordering the inner margins of the costal plaque, enlarged to meet the one on the clavus at claval suture and extending to cross-veins. A small black spot in apex of costal plaque and a much larger one in base of cell M_4 . Tegmina apically dusky.

Genitalia.—Pygofer hook single, sword-shaped, bent ventrally near its middle to about a 120 degree angle. Oedagus short and straight, with sharp heavy spine slightly anterior to the base of the shaft. (Pl. II, Figs. 15 and 15a).

Holotype, male; Culberson Co., Texas, July 10, 1927; R. H. Beamer. *Allotype*, female and 4 female paratypes, same data.

***Erythroneura coloradensis* (Gill.).**

This species was taken in numerous localities on wild grape.

***Erythroneura aprica* McAtee.**

This species was not taken but is included because it was named from the Santa Rita Mts., Arizona.

***Erythroneura ancora* n. sp.**

General ground color on vertex, pronotum and scutellum yellowish white, on tegmina whitish hyaline. Vertex marked with an inverted yellow V which continues on pronotum as a U. This U is as wide or wider than long. Sides of pronotum with an orange vitta almost its entire width. Lateral angles of scutellum yellow. Tegmina with the following orange markings: on clavus a vitta in touch with basal half of claval suture with a caudal projection which meets the tegminal suture and a spot almost to tip; on corium an oblique line arising near the humeral angle and meeting the middle of the claval vitta, another which borders the front and inner margins of the costal plaque uniting in a broad stripe with the claval vitta and near posterior end of costal plaque extending in an oblique line to unite with the base of cell M_4 in a narrowed vitta. Cross-veins red. Diagonal vitta along posterior end of costal plaque, spots in base of cell M_4 , and in apex of cell R_3 fuscous. Cells R_3 , M_2 , and M_4 slightly fumose.

Genitalia.—Pygofer hook U-shaped, typical of the *comes* group. Oedagus, viewed laterally, is long, curved almost into a circle and tapers rapidly from the base outward. (Pl. II, Figs. 11 and 11a).

This species resembles *gilensis* n. sp. externally, from which it may be separated by the U on pronotum instead of a Y, by the orange vitta of corium reaching the cross-veins and by the male genitalia.

Holotype, male; Culberson Co., Texas, July 10, 1927; R. H. Beamer. *Allotype*, female and one male paratype, same data.

Erythroneura anfracta n sp

General ground color pearly white tinged with yellow on vertex and pronotum. Vertex marked with a yellowish-orange inverted V which is continued on the pronotum in a Y. Lateral margins of pronotum with an orange bar extending almost to posterior margin. Tip of scutellum yellow, basal angles dusky yellow. Tegmina reddish orange, fumose in some places (basal two-thirds of clavus and just above the costal plaque), to the cross-veins with the following light areas: an oval spot at tip of scutellum, a diamond shaped area extending from middle of clavus to cross-veins and surrounding an orange spot at tip of clavus, a diagonal bar arising on costa between costal plaque and humeral angle and extending to claval suture, the costal plaque and a triangular area occupying space posterior to black bar at posterior end of costal plaque to cross-veins. Cross-veins red. An indefinite margined black bar arising near base of cell M_4 in a darker spot, extends diagonally to tip of cell R_3 ending likewise in a darker spot. Mesosternum more or less darkened.

Genitalia.—Pygofer hooks U-shaped, typical of the *comes* group. Oedagus heavy, ending in a triangular form with tube projecting. Two ventral processes arise near its base, curve up and out with a twist or turn near their base. This turn is more exaggerated in some specimens than in others. (Pl. II, Figs. 12 and 12a).

Holotype, male; Pinal Co., Arizona, August 6, 1927; R. H. Beamer. *Allotype*, female; same data. *Paratypes*, 44 males and 37 females, same data.

Erythroneura gilensis n sp

General ground color creamy white with the following orange markings: vertex, two posteriorly diverging vittae making an inverted V-shaped mark; pronotum, a broad Y-shaped vitta with arms and base of about equal width and length, a vitta on each lateral margin; scutellum, a solid spot or outline of one in each basal angle and a spot at the tip; tegmina, on clavus a vitta in touch with basal half of claval suture with a caudal barb which meets the tegminal suture and spot near tip of clavus; on corium an oblique line arising near the humeral angle and meeting the middle of the claval vitta, another which borders front and inner margins of costal plaque and then proceeds to the base of cell M_4 . An oblique dark mark in the apex of costal plaque; a black dot in the apex of cell R_3 and base of cell M_4 .

Genitalia.—Pygofer U-shaped. Oedagus heavy, with lateral wings near apex. A pair of processes arise ventrally near the base and, bending out near their middle, extend beyond the oedagus. (Pl. II, Figs. 14 and 14a).

This species belongs to the *comes* group of Robinson and is quite close to *E. beameri* Rob. It differs from that species in that the color markings are narrower throughout and in the characters presented by the male genitalia.

Holotype, male; Gila Co., Arizona, August 5, 1927; R. H. Beamer. *Allotype*, female, same data. *Paratypes*, 16 male and 7 females, same data; 2 males and 1 female, Tucson, Arizona, June 7, 1926, A. A. Nichol; 8 females and 9 males, Pinal Co., Arizona, 1927, R. H. Beamer.

***Erythroneura kiperi* n. sp.**

General ground color yellowish hyaline, slightly darker anteriorly, uniformly colored with the following exceptions: two small spots at base of scutellum brownish, tip of scutellum fuscous, small spot near center of clavi and faintly smoky area in region of cross-veins.

Genitalia.—Pygofer has large flat rectangular hook whose posterior corners project into two short diverging processes. Oedagus a straight heavy shaft ending in three small hooks. (Pl. II, Figs. 19 and 19a).

The tip of the scutellum turns up somewhat as in *Hymetta*, but it has no other resemblance to that genus.

Holotype, male; Mescal, Arizona, July 28, 1927; R. H. Beamer. *Allotype*, female, same data. *Paratypes*, 3 females and 9 males, same data; 1 female, Colfax Co., New Mexico, August 21, 1927; 21 females and 15 males, Cochise Co., Arizona, July 29, 1927; 1 male, Pinal Co., Arizona, July 27, 1927; R. H. Beamer.

***Erythroneura tricolor* n. sp.**

Ground color yellowish white. Vertex more nearly yellow in a large circular spot near middle. Pronotum with large rectangular area on center of disc with comma-shaped spot at each anterior corner of same color. Scutellum with a rectangular golden-yellow area at basal angles, median portion white tinged with yellow, tip more strongly colored. Tegmina covered from base to slightly beyond the costal plaques, except yellowish white rectangular areas near center of clavi, by a large blotch of red shading to fuscous on outer margin, this fuscous margin extending posteriorly to apex of tegmina; hyaline areas covering base of cell R, apex of cell R and M_2 . M_1 somewhat cloudy. Apex of clavi, first and second sectors and base of cell M_1 yellowish white.

Venter stramineous except a fuscous stripe beginning at posterior edge of thorax, extending anteriorly beneath base of wings, coloring ventral half of eyes and crossing the face in a strikingly distinct band.

Genitalia.—Pygofer with two hooks, the posterior one much longer than the other. Oedagus, viewed laterally, resembles an S ending in a knob with a backward projecting process. (Pl. II, Figs. 18 and 18a).

Holotype, male; Huachuca Mts., Arizona, August 1, 1927; R. H. Beamer. *Allotype*, female; and *Paratypes*, 7 females and 5 males, same data.

All specimens were swept from oak on the east side of Car Peak, Huachuca Mts., Arizona.

***Erythroneura milleri* n. sp**

General ground color semi-hyaline to yellowish white. Apex of vertex without black spots in most specimens; those from Arizona with black spots. Vertex pronotum and scutellum each with a pair of orange spots which form two parallel longitudinal rows. Extreme apex of scutellum also orange. Clavi with an indefinite orange anchor-shaped spot occupying most of basal two-thirds. Cell Cu beginning at posterior end of this anchor mark in clavus more or less orange almost to cross-veins. Slightly smoky in region of cross-veins. Some specimens more or less orange blotched about costal plaque.

Genitalia.—Pygofer hook a short heavy spine-like process. Oedagus viewed laterally, characterized by a very heavy base and a long curving shaft which in contour resembles that of *ancora* n. sp. except it is much more slender near the base, enlarging distally and ending in a slender recurved tip. A straight process projects into the hollow formed by the curve of the base of the shaft. (Pl. II, Figs. 16 and 16a).

Holotype, male; Culberson Co., Texas, July 10, 1927; R. H. Beamer. *Allotype*, female; *Paratypes*, females 7 and males 7, same data; 3 males, Gila Co., Arizona, August 5, 1927; R. H. Beamer; 1 female, Huachuca Mts., Arizona, August 1, 1927; R. H. Beamer.

***Erythroneura illinoiensis* (Gill.).**

This beautiful species was taken commonly where wild grape occurred.

***Erythroneura illinoiensis* var. *regalis* var. new.**

General ground color yellowish white. Vertex with a bright red triangular spot near middle, pronotum with a square spot near middle and scutellum with apex and a spot at each basal angle of same brilliant red color. Clavi marked with indefinite golden-yellow anchor in basal two-thirds and small spot of same color near tip. Coria marked with a sooty-black blotch of about the size and shape of costal plaque, located between cubitus and anal vein opposite costal plaque; a small sooty-black spot near posterior end of costal plaque and a larger spot of same color at base of cell M_4 . Extreme tips of tegmina more or less fumose. Large red spot on side of mesothorax.

This variety may be separated from *illinoiensis* (Gill.) by the elongated black sooty patches on the corium.

Holotype, male; Oak Creek Canyon, Arizona, August 14, 1927; R. H. Beamer. *Allotype*, female and *Paratypes*, 7 females and 6 males, same data.

Erythroneura rubicunda n. sp.

Ground color white tinged with yellow. White markings of vertex arranged crosswise in two rows of three spots each, the center spot of each row connected forming a mesal longitudinal white mark. The outer spots roughly triangular and larger than the median ones. Between the white spots orange. Pronotum occupied by two large orange triangles except a white inverted T whose base separates these triangles. Base of the T between triangles enlarging anteriorly. Crossbar of T occupying entire base of pronotum. Each orange triangle with two definite white spots. Scutellum orange except a mesal rectangular spot near base and two lateral triangular spots. Tegmina with the following orange marks: clavus with a large basal spot touching claval suture on one side but not reaching inner margin, a median spot one of whose sides is on claval suture the other on inner margin, as long as broad, and a third smaller spot almost to tip. Corium orange to red throughout except an area about the costal plaque which reaches to claval suture between first and second claval spots, an area more or less irregular-sided beginning opposite last claval spot and running roughly parallel to cross-veins to radius which are white and apex of cells M and Cu which are fuscous. Costal plaques are white tinged with purple and more or less bordered with red on inner side. Cross-veins white. Beyond cross-veins fuscous. Face red with four white spots on anterior border. Three spots of the vertex also extend down on face. Length 2.7. mm.

Holotype, female; Pinal Co., Arizona, August 6, 1927; R. H. Beamer.

Erythroneura variabilis n. sp.

General ground color dark, varying from fumose through green to red, with the following light areas: on vertex white band on margin from eye to eye and three white spots connected with base by a narrower line; on pronotum three oval white spots slightly posterior to anterior margin with long axis longitudinal, in some specimens they tend to be longitudinal stripes, and two triangular areas on base either side of median line; on scutellum a median vitta more or less definite with lighter blotches either side of tip; tegmina, on clavus a large sinuate area bordering scutellum and crossing to or nearly to the claval suture near its middle, another diagonal spot two-thirds of distance to tip; on corium a definite area continuing from the last claval spot following cell Cu more or less interrupted, ending on margin of tegmen at tip of clavus, a more or less definite area beginning at posterior end of first claval area running diagonally to cell M following it almost to cross-veins; costal plaque yellowish white set off at either end by an oblique darker vitta. A yellowish-white spot between the posterior darker area and cross-veins. Cross-veins, cell R_1 , base of cell R_3 and apex of cell M_4 light, remainder fuscous. Vein R_1 red.

Genitalia.—Pygofer hook a bifid process, the inner much shorter than the outer. It is this character which separates this species from *E. vulnerata* Fitch. (Pl. II, Figs. 20 and 20a).

The markings of this species, both light and dark, are exceedingly variable. The wing venation places it in the *vulnerata* group where it runs down to *vulnerata* Fitch, from which it is quite distinct according to the male genitalia. This is one of the common destructive species of *Erythroneura* on grape in Arizona.

Holotype, male, Yavapai Co., Arizona, August 9, 1927; R. H. Beamer. *Allotype*, female; Coconino Co., Arizona, August 18, 1927; L. D. Anderson. *Paratypes*, 400 males and females from various localities in Arizona.

***Erythroneura grandis* n. sp.**

General ground color yellowish white. Vertex red with the following yellowish white spots: a row of five connected spots on apex extending between the eyes, the lateral ones much smaller and a spot in each basal angle touching the eye. Pronotum dark red except basal third and several small spots along anterior margin. Scutellum dark red in holotype although the allotype has the basal angles slightly lighter. Tegmina to cross-veins brick red with the following light areas: a narrow cross band just posterior to tip of scutellum extending almost to costal margin, an irregular sided circle about red marks near tips of clavi, the apices of the sectors and in some specimens more or less of second sector. Cross-veins light. Beyond cross-veins dark with lighter areas. Costal plaque light creamy yellow splotted with purple and red. Venter fuscous, mesosternum bluish black, face red with the following light spots: a small spot above base of each antenna and an anteriorly projecting club-shaped spot between them. Length of female 3.7 mm.

Genitalia.—Pygofer hooks two. Oedagus broad in lateral view with a heavy base and upward projecting tip. A pair of processes arise at base of shaft bending out at right angles about one-fourth distance from tip.

Holotype, male; Oak Creek Canyon, Arizona, August 14, 1927; R. H. Beamer. *Allotype*, female, same data. *Paratype*, male and female, same data. One male, Huachuca Mts., Arizona, August 1, 1927; R. H. Beamer.

This species has somewhat the same general appearance as *rubicunda* n. sp., but is about a third longer and has fewer white markings on pronotum and vertex.



1. *obscura*

1a.

2. *canyonensis*

2a.

3. *nicholi*



4. *pinalensis*

4a.

5. *tripunctata*

5a.

3a.



6. *pallenta*

6a.

7. *cimarroni*

7a.

8. *casta*



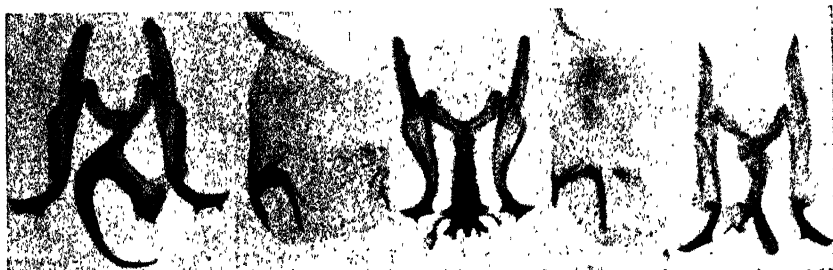
9. *unicolor*

9a.

10. *triceroprocta*

10a.

8a.



11. *ancora*

11a.

12. *anfracta*

12a.

13. *carmini*



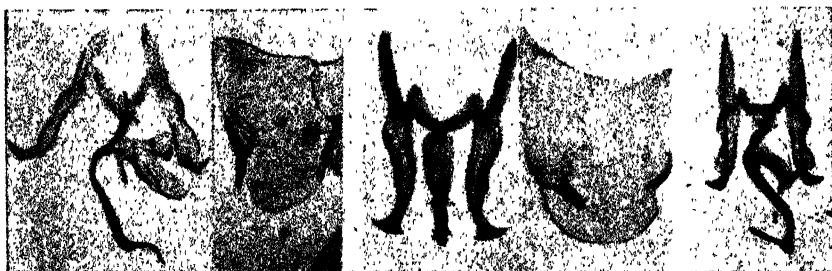
14. *gilensis*

14a.

15. *texana*

15a.

13a.



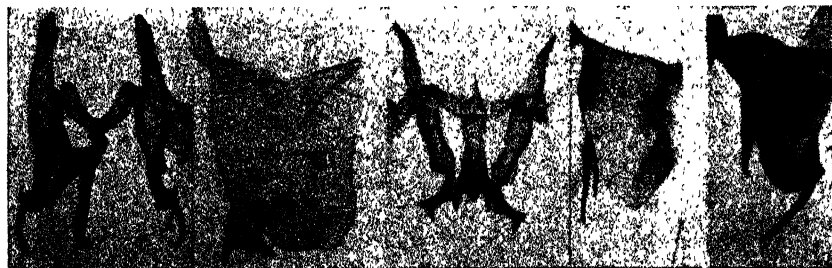
16. *milleri*

16a.

17. *illinoiensis*
var. *regalis*

17a.

18. *tricolor*



19. *hiperi*

19a.

20. *variabilis*

20a.

18a.

A LEAFHOPPER PARASITE—POLYNEMA SAGA (GIRAULT).

(Hymenoptera, Mymaridae)

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During the summer of 1927, the writer became interested in the life history of the leafhopper, *Euscelis stactogalus*, which was then unusually abundant on some tamarix bushes near the laboratory. The insects were actually numerous enough to discolor these very hardy plants quite seriously. Under such conditions, it was very easy to find a large number of the eggs, which are deposited in the newer stems.

While examining some of these eggs under the binocular, one day, a tiny parasite ran into the field of vision and was seen to oviposit in several eggs after first carefully examining them with its antennæ. This led to further observations and finally a number of tamarix twigs bearing hundreds of leafhopper eggs were placed in large test tubes and the parasites allowed to emerge. In this way, hundreds of these minute insects were obtained, for they seemed to have parasitized over ninety per cent of the overwintering eggs in these particular bushes.

The parasites were determined by Mr. A. B. Gahan as *Polynema saga* (Girault), which species has hitherto been known only from the type specimen in the United States National Museum. This specimen was taken by H. S. Barber at Washington, D. C., 31-7-05.

It seems fairly certain that this parasite could be found readily wherever *Euscelis stactogalus* is abundant, and it is apparently an important factor in the life history of this leafhopper, since due to the severe parasitism of 1927, the 1928 broods on the same bushes have been very much smaller. It will be interesting to bear this parasite in mind when examining the eggs of other species of leafhoppers.

THE INJURY TO NESTLING BIRDS BY THE LARVAE OF PROTOCOLLIPHORA.

CHARLES W. JOHNSON.
Boston Society of Natural History.

The effect of the bloodsucking larvæ of *Protocalliphora* on nestling birds has heretofore received comparatively little attention. The habit of the larvæ of usually hiding in the nest by day and coming forth at night to feed upon the blood of their hosts, is undoubtedly the reason why they have escaped the attention of most ornithologists. To the entomologists the fly was usually considered rare as very few were taken by the ordinary methods of collecting. No one realized how abundant the flies really were until the actual breeding places of the flies were studied. Thus comparatively little progress has been made toward a knowledge of their habits since their injury to nestling birds was recorded near Boston twenty years ago.

Through the cooperation of a number of persons interested in bird-banding I have been making some studies on the effect of the larvæ of species of *Protocalliphora* on nestling birds. To further increase an interest in this work among the bird-banders and other bird lovers, my notes have been published in the *Bulletin of the Northeastern Bird-Banding Association*, and have thus probably escaped the attention of most entomologists. I will therefore briefly review the subject together with my notes for 1928.

In 1908 W. H. Henshaw recorded two successive broods of Bluebirds at Wellesley Hills, Mass., infested by the larvæ of *Protocalliphora*, in which seven of the eight nestling birds were destroyed. In 1915 Albert F. Coutant made a biological study of the *Protocalliphora* infesting the Common Crow and the Chipping Sparrow at Ithaca, N. Y. In 1919 O. E. Plath published some interesting papers on the occurrence and habits of *Protocalliphora* infesting some ten species of birds, in the vicinity of San Francisco, California and the Puget Sound region. He states that from five to ten per cent of the nestling birds die from the attacks of these parasites, while

others are so weakened by the loss of blood that they fall an easy prey to rapacious animals. In 1922 Prof. M. Bezzi published a paper on the species of *Protocalliphora* of Europe and North America.

In the above mentioned papers the flies were referred to the European species *Protocalliphora azurea* Fallen and *P. chrysorrhea* Meigen, but studies made by R. C. Shannon and I. D. Dobrosky in 1924 show the American species to be distinct. An interesting paper on the external parasites of birds by Irene D. Dobrosky appeared in 1925. The work was done at Ithaca, N. Y., and shows the nests of the Bluebird and House Wren, especially the former, badly infested by *Protocalliphora*.

In the Bulletin (Jan., 1927) above referred to, I published my notes for 1926. A Bluebird's nest received from A. W. Higgins, Rock, Mass., contained 154 larvæ and puparia of *Protocalliphora splendida* var. *sialia* Shann. and Dobr. Owing to unfavorable conditions in shipping, only 24 flies emerged and from 17 of the puparia 202 chalcids issued, determined by A. B. Gahan as *Mormoniella brevicornis* Ashm. Two of the five birds were weak and unable to leave the nest. A second Bluebird nest from J. D. Smith, Needham, Mass., contained 33 puparia from which emerged 21 flies, while four were parasitized by the above mentioned chalcid.

In 1927 through the kindness of Messrs. L. W. and J. D. Smith, I was able to examine the nests of seven Bluebirds and four Tree Swallows. Two nests each contained three dead Bluebirds and two nests each one dead Tree Swallow. The number of larvæ and puparia in the Bluebird nests varied from 14 to 130, a total of 387, an average of about 55 per nest. No chalcids were observed in two of the nests. The other nests showed parasitism varying from 31 to 88 per cent, an average of about 54 per cent. A small tachinid *Plectops pruinosa* Mall. was obtained from two of the Bluebird nests. The Tree Swallows' nests which were infested by the same *Protocalliphora* contained from 10 to 89 puparia, a total of 220, an average of 55 per nest, the parasitism occurring in these nests varying from 10 to 78 per cent, an average of 51 per cent.

An interesting nest was that of the Crested Flycatcher, representing a new host for *P. splendida sialia*. It was obtained by Mr. A. W. Higgins at Rock, Mass., June 30.

The maggots caused the death of two of the nestlings. Mr. Higgins counted 95 maggots, but when the box reached me some had escaped and I could count only 71. On July 14 and 15, 29 flies emerged, from the other 42 puparia no flies issued. No parasitism was noticed.

On July 19 Mr. Higgins sent me a Bluebird nest containing 111 puparia, from 13 of which flies emerged. From 48 flies failed to issue and 50 were parasitized by the above mentioned chalcid, a parasitism of 54 per cent. Following the parasites the nest became alive with fleas, *Ceratophyllus* sp.

The most interesting nest of the season was that of the Black-throated Blue Warbler, from Ashland, N. H., obtained by Mrs. R. B. Harding. There were 38 puparia in the nest, from which emerged 35 flies, (9 males and 26 females). All the flies were the typical *P. splendida* Macq. with no marked evidence of sexual dichromatism as advanced by Shannon and Dobrosky in 1924. While the pollinose covering on the thorax is less evident in the male than in the female, the abdomens in both are alike, grayish pollinose, with the last segment coppery. In *sialia* the entire body is a dark, shining blue.

Miss Helen J. Robinson of Brewer, Maine, reported the death of nestling Bluebirds, May 26, and Mr. Edward H. Forbush sent larvæ of *Protocalliphora* taken from a Bluebird's nest in a bird-box at North Middleboro, Mass. There were two dead birds in this nest.

In 1924 I obtained from Mr. J. S. Pfeil two maggots taken from swellings on the neck of a sparrow found near Middleboro, Mass. The larvæ pupated August 3, and the adults (a male and female) emerged August 12. This was recorded in 1925 as *Protocalliphora hirudo* var. *cuprea* Shann. and Dobr., and constitutes the only eastern record for the species. It was described in 1924 from Seattle, Wash., from the nest of a Western Robin.

During the summer of 1928 the following nests were examined. On June 18, a Bluebird's nest received from Mrs. E. L. Hathaway, of West Bridgewater, Mass., containing 58 puparia. Forty-one flies emerged and 16 puparia were parasitized by the chalcid mentioned, a parasitism of about 28 percent. On July 24 Mrs. Hathaway sent me the nest of the second brood of the Bluebird. When banding the nestlings

she had found four of the maggots clinging to the bird. There were two sizes of larvæ in the nest, but all apparently pupated, although 19 were quite small, due no doubt to underfeeding. The total number of puparia was 153. Flies emerged from 38, from 26 flies failed to issue, and 89 were parasitized, the total parasitism being about 58 per cent.

On July 7 a Barn Swallow's nest was received from Mrs. Karl G. Wormuth of Belmont, Mass. It contained 51 large maggots, which had probably driven the nestling birds from the nest during the night, as they were found dead in the morning on the floor of the barn. Only 39 flies emerged from the puparia. There was no parasitism. Mr. H. E. Woods reported Barn Swallows infested by *Protocalliphora* in 1925.

From the puparia in the nest of a Chestnut-sided Warbler collected near Ashland, N. H., Mrs. R. B. Harding obtained seven specimens of the typical *P. splendida*. From the puparia in the nest of a Robin also collected near Ashland, N. H., Mrs. Harding obtained 39 flies, apparently the same as those infesting the Bluebirds. In neither case did I see the puparia, so that parasitism, if present, could not be noted.

The above notes are sufficient to show that the larvæ of *Protocalliphora* are a serious menace to nestling birds and that measures should be taken to check their depredations. Parasitism is a factor in diminishing their number, but the percentage thus destroyed is at present considerably below what is called "Nature's balance." When nests are accessible, especially in bird houses, I would suggest that the first nests be destroyed as soon as the nestlings leave the nest. With the second brood however, it would seem best to wait about a month before destroying the nests, thus enabling the parasites to escape. There is usually a greater amount of parasitism in the second than in the first brood. There seems to be little doubt but that the adult female hibernates during the winter and in the spring oviposits in the nest when conditions are favorable for the young larvæ.

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BOOK NOTICE

PRINCIPLES OF FOREST ENTOMOLOGY, By SAMUEL A. GRAHAM, XIV + 339 pages, 149 figures. *McGraw-Hill Book Co.*, New York, 1928.

This is a book written primarily for teachers of forest entomology but will be of interest to economic entomologists, ecologists, foresters and to many others engaged in growing or utilizing forest products. It deals with the theory of forest preservation against insect attack, with situations and methods, giving a minimum of space to descriptions of injurious species of insects. C. H. K.

THE TEACHING OF MEDICAL ENTOMOLOGY*

WILLIAM A. RILEY,

Department of Zoology, University of Minnesota.

The teaching of a subject which is growing as rapidly as medical entomology cannot be reduced to a common formula. Even if such a standardization were possible, there is little basis for supposing that any real progress would result through it.

To be sure, there are in the educational world of today two counter currents as regards outlined courses. The one has as its goal standardized courses leading to uniformity and to ease of evaluation on academic records. The other leaves much to the initiative of the individual teacher, the course to be determined largely by his own conceptions of the subject and of the best methods of passing it on to his students.

My own belief is that the second tendency is the sounder, in so far as college courses are concerned. My efforts during the past fifteen years have not been directed towards the attempt to find ready-made or to develop a universally applicable course of medical entomology but rather towards the meeting of the needs of the groups of students with which I have come in contact. Each year impresses me with the diversity of these needs and with the difficulties involved in trying to meet them. Far from bringing discouragement, they add zest to the problem. It is, then, with the idea of opening up the subject rather than with any thought of outlining a model course, that I present some of the problems which I have encountered and indicate in broad outline the manner in which I have tried to meet them.

Granting that an independent general introductory course in medical entomology is to be given, several important questions must immediately be considered. What classes of students seek such a course and what is their preparation? What are

*A section of a symposium on "The Teaching of Parasitology," presented before the American Society of Parasitologists.

the broad outlines of such a course and what are some of the ways in which the work may be adapted to special groups?

When I was first called upon to present a course in medical entomology, I had the relatively simple problem of dealing with a group of advanced students, all of whom had a background of elementary zoology and of general entomology. The majority of them had had a considerable amount of training in the latter field. It was a stimulating group but not a typical one.

Very soon it became apparent that the importance of the rapidly growing field was attracting a very heterogeneous group. This seems to be the situation in most of the institutions in which the subject is now being developed.

In the first place, there are students of zoology and of entomology who wish to round out their regular courses by more detailed information regarding the revolutionary discoveries of the relation of arthropods to their symbionts and to disease of man and animals. A few of these have already decided that they wish to do advanced work in the subject. Others are looking forward to the teaching of entomology or to practical field work in insect control. In the same group will be a number of premedical and medical students interested because of the bearing of the subject on their chosen life work. Similarly, occasional health officers or social science workers may desire an introduction to the subject or even special training. What common background can be expected of such a class?

It would seem hardly necessary to say that a brief course in medical entomology of college grade cannot be given without a prerequisite of a thorough course in general zoology. In the few schools where it is still believed that entomology is a subject apart and can be presented without a background of zoology, the training already gained in systematic entomology will permit of substitution in the way of elementary zoology but under such conditions it is exceedingly difficult to give a balanced course in the subject.

Beyond the general zoology, there will still be great diversity of preparation and whenever it is possible the students should be grouped in special sections. This is not feasible under conditions prevailing in most institutions. Assuming that the students are to be handled in a single class and have only a zoology prerequisite, there are certain basic needs to be met in the presentation of the subject.

The student must know that names and characteristics of the chief arthropod groups with which he is to deal, and the general position of the phylum.

He must know sources of information, not merely a single text, however good, but the various available texts and, by all means, methods of getting at the original contributions to the subject. However exaggerated the statement may be that texts are books in which we embalm truths, it must nevertheless be recognized that in a rapidly growing field of knowledge no one who ignores the current literature can rank as a scholar. One of the most important duties of a teacher is to impress this fact upon his students.

On the other hand, the student must gain an appreciation of the pioneer work in medical entomology and of its bearing upon present and future work. The teacher of medical entomology or of any phase of science needs often to remind himself and his students of Emerson's statement that "coming Time already waits unseen yet definitely shaped, predetermined and inevitable in the Time come; and only by the continuation of both is the meaning of either completed."

Following this introductory material the course may take up in systematic order the poisonous and the simple parasitic arthropods emphasizing in so far as time will permit, their morphology, life histories and general biology, their effects on man and animals, sources of infestation, and methods of offense and defense against them. In this connection mention should be made of their role as transmitters of diseases but I prefer to take up the details of that aspect of the subject later, discussing the various insect-borne diseases, their causative organisms, the manner in which they are conveyed and the methods by which they have been, or may be controlled.

Finally, there is given a résumé of the advances already made, the present day status of the problems and of the outlook for the future.

The course combines lecture, recitation, and laboratory work. At the first lecture period the students are given a list of the major groups which are to be most frequently mentioned. This is by way of review for it has already been presented in the course in General Zoology. Needless to say, it appears wholly new to most of the class—the examinations are passed and who ever suspected that there would be any

further use for such details? By way of emphasizing the review two early laboratory periods are devoted to determining an assortment of arthropods to classes, and a considerable number of insects to orders.

One or more laboratory periods, and assignments throughout the term are devoted to becoming acquainted with source material in the literature. There are placed before the student significant copies of the leading journals of importance to the worker in medical entomology. Similarly, he is made acquainted with the publications of the United States Public Health Service, the Bureau of Entomology, and the Bureau of Animal Industry. Particular attention is given to the abstract journals in English, French and German, and to such aids as the *Index Medicus*, *Quarterly Cumulative Index*, the *Catalogue of the Surgeon General's Library*, and the *Zoological Record*. Assigned topics give practice in the use of these various publications.

For the historical aspects the student is encouraged to look up the original reports of epoch-making discoveries and to read contemporaneous comments and criticisms which these reports aroused. So new is the field that any good university library will afford opportunities for such reading—a medical collection will broaden the opportunity, but even a good public library will offer much of value. Old files of *Harpers Weekly*, the *North American Review*, and other secular magazines well repay browsing. Incidentally, I suggest also the reading of some of the great historical novels such as Manzoni's "The Betrothed," Ainsworth's "Old St. Paul's," Charles Brockton Brown's "Arthur Merwyn," and Defoe's "Journal of the Plague Year" which have their setting in periods of great epidemics.

Beyond the preliminary very general work in classification the laboratory work affords opportunity for getting acquainted with the mature and immature stages of the principal forms of importance but no attempt is made to drill the students in special taxonomy. If such training is desired it is afforded in other courses.

It is very desirable to require a preliminary course in the principles of animal parasitism, in which considerable stress is put upon the parasitic protozoa and the helminths. In case the class has not that preparation, a study is made not only of vectors, but important pathogens, such as living and stained trypanosomes, malarial parasites, filariæ, and cestode larvæ

dependent upon insects. Whenever feasible, forms parasitizing domesticated and feral animals are used.

Such a course as I have broadly outlined is designed as a survey course. The student with a good background of general zoology, entomology, and supporting subjects and with a fairly definite plan of work should be treated individually and given opportunity for such special preparation as may seem most advantageous. This may take the form of special taxonomic or life history or ecological work on the mature or immature forms of arthropods of medical importance, or of their parasites and their relations to these, or it may be any one of the many special problems.

If he has in mind preparing himself for special work in medical entomology, he will probably find the survey course a helpful introduction but it is essential that he be impressed immediately by the breadth of the field. Its scope is a wide one and touches upon very many of the most rapidly growing phases of pure and applied biology. No longer can the systematist trained in the determination of larval and adult mosquitoes qualify by that alone as a medical entomologist. The field worker who can locate the breeding places of mosquitoes and distinguish the anophelines in their various stages is indispensable, but if he wishes to be more than a technician he soon learns that medical entomology demands other preparation and interests. The day is long past when a worker could dip a housefly into a culture of bacteria, transfer it to a sterile plate and seriously suggest that he had thereby established the fact that these insects played an important role in the transmission of disease.

He must be impressed, then, by the necessity for broad fundamental preparation. As early as possible in his course he should get his equipment of modern languages—a need all too often overlooked until the crowded days of graduate work. His zoological training should include not only entomology but ecology, experimental zoology, protozoology, and helminthology. Bacteriology, histology and pathology are supporting subjects of great importance. If one is to do sound research work on the insect vectors of the parasitic protozoa it is essential that he have a thorough knowledge of the normal anatomy and histology of his subjects. The zoological work mentioned presupposes training in chemistry and biochemistry

but it is well to emphasize especially the need of preparation along these lines and in general physiology for the man who plans to take up serious work in medical entomology. The training in general botany should, if possible, be supplemented by courses in mycology and in plant pathology for these open up border-line fields of growing significance to the animal parasitologist. Of the many other subjects which will bear upon his work, one which is in danger of being overlooked but which is becoming an essential tool of the biologist is that of biometry. Advantage should be taken early of any opportunity to add this to the courses elected.

To attempt to list the subjects which would be of use to the prospective research worker would be an absurdity. The business of medical entomology as Alcock has expressed it, "is, in the case of any species convicted on pathological evidence of being a standing danger to the public health, to unriddle its biology in every detail, and to investigate all the varying circumstances that influence its acquisition and retention of pathogenic capacity." A broad contract it is and one which challenges the best training which a man can bring to it. Fortunate is the teacher who can leave with his students this conception rather than merely a mass of data of presumably immediate applicability.

EUGENE AMANDUS SCHWARZ

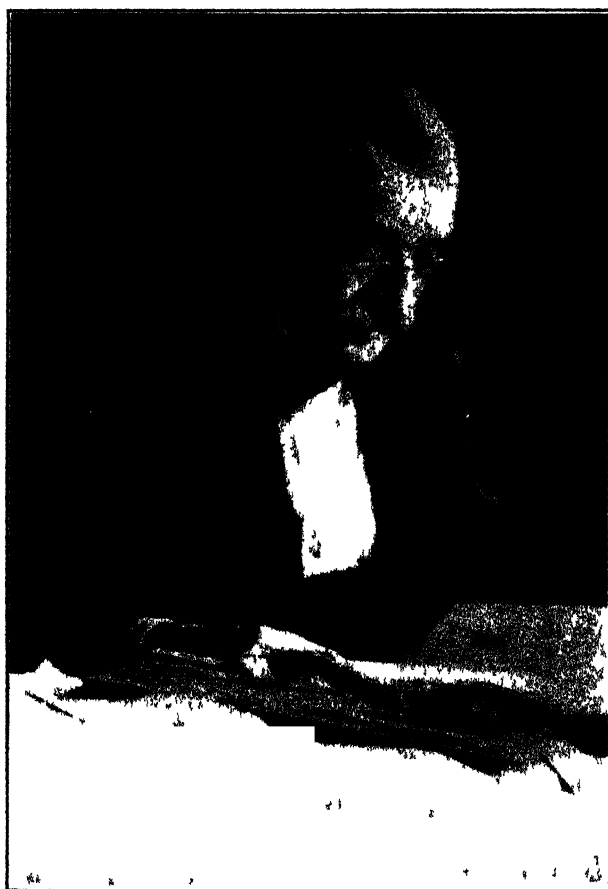
Dr. E. A. Schwarz, an Honorary Fellow of the Entomological Society of America, died in Washington on October 15, 1928, at the age of eighty-four years and six months. Of that long life, fifty-five years were spent in this country, and more than fifty of those years in the service of the United States government. Doctor Schwarz was made an honorary member of the Entomological Society of America in 1914. He had for a long time been the only honorary member of the New York Entomological Society. In 1916 he was made Honorary President for life of the Entomological Society of Washington, after an amendment to the constitution had been adopted creating this honorary office. In 1923, the University of Maryland made him Doctor of Science. (*honoris causa*). In August, last, the Fourth International Congress of Entomology, meeting at Ithaca, sent him a special telegram of greeting and respect.

Doctor Schwarz was born at Liegnitz, Silesia, April 21, 1844. As a boy he became interested in entomology and later was a student at the University of Breslau. After the Franco-Prussian War, he was a student for some time at the University of Leipzig. In December, 1872, he came to the United States and became an assistant to H. A. Hagen at Cambridge, Mass. In 1874 he went with H. G. Hubbard to Detroit where they founded the Detroit Scientific Association and built up a collection of insects. With Hubbard he made explorations in Florida and in the Lake Superior region, and published papers on the Coleoptera of those regions.

In the summer of 1878, on recommendation of Dr. J. L. LeConte, he was taken on as an assistant to C. V. Riley in Washington in the closing work of the U. S. Entomological Commission. On November 15, 1878, he was definitely appointed an Assistant in the U. S. Department of Agriculture. He remained with the Department of Agriculture until August 27, 1926, when he was pensioned and retired for age.

For many years previous to his retirement he had been Custodian of the Coleoptera in the U. S. National Museum and, although paid by the Department of Agriculture, his work was done mainly in the Museum. After his retirement he continued his Museum work.

Doctor Schwarz was one of the most learned entomologists in the United States. He was an exceedingly close observer, a great collector, and a very broad student of entomology, attracted to both the taxonomic and the biological sides of the study of insects. He was a great mine of information and was consulted by younger men all the time. In the course of his more than fifty years at Washington, he made many expeditions both privately and officially. In these expeditions he covered practically all parts of the United States, and also spent some



EUGENE AMANDUS SCHWARZ

months in Panama, Guatemala, Mexico and Cuba. One of his expeditions also took him into British Columbia. He published no *magnum opus*, but very many short papers, all of great merit. He shunned publicity, and yet he was known among the entomologists of this country, and of other countries as well, as a man of very great learning and of the highest standing. His influence on the character of American entomology was very great. He was one of the kindest souls that ever lived, and hundreds of younger workers have acknowledged their gratitude to him for help that he had given them. It was the custom of entomologists for many years when visiting Washington to consult him about their troubles.

In 1926 he had a slight stroke, and from that time on was not able to express himself coherently. Although he remained apparently unimpaired in intellect, his decline dated from that time.

The Entomological Society of Washington has devoted the December, 1928, number of its Proceedings to his memory, and that part contains a long memorial sketch by H. S. Barber, A. Busck and the writer, a map of Doctor Schwarz' collecting trips and a bibliographical list compiled by Miss M. Colcord.

L. O. HOWARD.

PROCEEDINGS OF THE TWENTY-THIRD ANNUAL MEETING.

New York, N. Y., December 27th and 28th, 1928.

The twenty-third annual meeting of the Entomological Society of America was held at New York, December 27th and 28th, 1928. The program covered a large variety of topics and included many interesting and important contributions. The attendance ranged from 60 to 110, with a total of approximately 180 members present at one or more sessions.

The Annual Public Address was delivered by Dr. Royal N. Chapman. Doctor Chapman's address, entitled, "The Potentialities of Entomology," was greatly appreciated and thoroughly enjoyed by everyone present. The symposium, "Present Trends in Systematic Entomology," which was presented by C. T. Brues, W. T. M. Forbes, J. A. Hyslop, J. C. Bequaert, J. A. G. Rehn, and J. N. Aldrich, was well received and aroused much interest.

Opening Session, Thursday Morning, December 27th.

The Society was called to order at 10:45 A. M., by President E. O. Essig, in Room 411, Main Hall, Teachers College, Columbia University, New York. Attendance, 100. The following papers were presented:

1. Sentiment in Entomology. E. O. ESSIG, University of California.
2. Early Official Entomologists in New York State and Their Work. E. P. FELT, Bartlett Research Laboratory.
3. The Brooklyn and New York Entomological Societies, Past and Present. G. P. ENGELHARDT, Brooklyn Museum.
4. A Method for Obtaining Ecto-Parasites of Birds and Mammals. W. E. DOVE, U. S. Bureau of Entomology.
5. The Injury to Nesting Birds by the Larvæ of Protocalliphora. CHAS. W. JOHNSON, Boston Society of Natural History.
6. Soil Animals Injurious to Sugarcane Roots. HERBERT SPENCER and CHARLES L. STRACENER, Louisiana Agricultural Experiment Station.
7. Biology of Plecoptera. P. W. CLAASSEN, Cornell University.
8. Some Experiments with Insects. FRANK E. LUTZ, American Museum of Natural History.
9. A Season's Leafhopper Collecting at Trap Lights. PAUL B. LAWSON, University of Kansas.
10. New Genera and Subgenera from the Genus *Deltocephalus*. D. M. DELONG and J. P. SLEESMAN, Ohio State University.
11. Larval Structure in the Dryopidæ. LUTHER S. WEST, Battle Creek College.

The following committees were appointed by President Essig:

Nominating Committee—F. E. LUTZ, Chairman; E. P. FELT, H. OSBORN.

Auditing Committee—C. J. DRAKE, Chairman; J. S. HOUSER, B. A. PORTER.

Resolutions Committee—D. M. DELONG, Chairman; J. M. ALDRICH, P. B. LAWSON.

Moved and carried that DOCTOR FELT's photograph be included with the other New York entomologists, if DOCTOR FELT's paper, presented at this session, is published.

Second Session, Thursday Afternoon, December 27th.

The Society was called to order at 1:35 P. M. Attendance, 100. The following symposium was presented:

PRESENT TRENDS IN SYSTEMATIC ENTOMOLOGY.

Introductory Remarks	C. T. BRUES
1. Nomenclature	
a. Scientific Names	W. T. M. FORBES
b. Common Names	J. A. HYSLOP
2. Descriptions	J. C. BEQUAERT
3. Modern Methods of Making and Preserving Collections	J. A. G. REHN
4. Museums and Depositories	J. M. ALDRICH
Concluding Remarks	C. T. BRUES

Third Session, Friday Morning, December 28th.

The Society was called to order at 10:00 A. M. The following papers were presented:

12. Senses of Lepidoptera. N. E. MCINDOO, U. S. Bureau of Entomology.
13. The Pedipalp Sense Organ of the Solpugid *Eremobates sulphurea*. HELEN E. MURPHY, University of New Mexico.
14. On the Bionomics of a Primary Parasite and of Two Hyperparasites of the Geranium Aphid GRACE H. GRISWOLD, Cornell University.
15. *Aphelinus mali* and Its Travels. L. O. HOWARD, U. S. Bureau of Entomology.
16. Some Erythroneura (Homoptera-Cicadellidæ) from the Southwest. R. H. BEAMER, University of Kansas.
17. The Taxonomic Value of the Embolus in the Erigoneæ. C. R. CROSBY, Cornell University.
18. High Altitude Syrphidæ (Diptera) from Pingree Park, Colorado, with Descriptions of New Species. CHAS. L. FLUKE, JR., University of Wisconsin.
19. The Folded-Winged Wasps of the Bermudas, with some Remarks on Insular Wasp Faunas. JOS. BEQUAERT, Harvard Medical School.
20. Notes on Coleoptera Taken from Bait Pails. S. W. FROST, Pennsylvania Agricultural Experiment Station, and HENRY DIETRICH, Appleton, N. Y.
21. Notes on the Coleoptera Fauna of Western Washington, with the Record of Four Introduced European Carabidæ. MELVILLE H. HATCH, University of Washington.
22. Some Facts Relative to the Effects of High Frequency Radio Waves on Insect Activity. THOMAS J. HEADLEE, New Jersey Agricultural Experiment Station.
23. Surgical Shock of Insects and Recovery. WM. ROBINSON, University of Minnesota.
24. Absolute Humidity as a Factor in Insect Hardiness. NELLIE M. PAYNE, University of Pennsylvania.

Fourth Session, Friday Afternoon, December 28th.

The Society was called to order at 1:30 P. M. Attendance, 65. The following program was presented:

25. Studies in the History of Coleopterology from Aristotle to Linnaeus. MELVILLE H. HATCH, University of Washington.

26. The Detection and Estimation of Insect Chitin and the Irrelation of Chitinization to Hardness and Pigmentation of the Cuticula of the American Cockroach. F. LESLIE CAMPBELL, U. S. Bureau of Entomology.
27. The Mating Flight and the Vestigial Structure of the Mayfly, *Campsurus*. ANN H. MORGAN, Mount Holyoke College.
28. The Metamorphosis of a Mid-Intestinal Gland (Chrysomelidæ). WILLIAM C. WOODS, Kent School.

The Annual Business Meeting followed the reading of papers, as follows:

REPORT OF THE SECRETARY.

Previous to July 1, 1928, the following, having been duly nominated and recommended, were elected members of the Society by mail ballot of the Executive Committee:

- T. E. ADKINS, 309 Aztec Bldg., San Antonio, Texas.
 F. F. BIBBY, Agricultural Experiment Station, A. & M. College, College Station, Texas.
 DONALD JOYCE BORROR, 149 W. Park St., Westerville, Ohio.
 THEODORE H. BURRIS, Route B, No. 10, Ballinger, Texas.
 FRANK D. DEGANT, 3401 Wade Ave., Cleveland, Ohio.
 FREDERICK COURTNEY GILLIATT, Entomological Laboratory, Annapolis Royal, N. S., Canada.
 LYSBETH LOUISE HAMILTON, Department Zoology, University of Pittsburgh, Pittsburgh, Pa.
 J. R. HILTZ, 240 Florence Ave., Pontiac, Mich.
 J. W. INGRAM, Box 164, Crowley, La.
 RALPH R. MILLER, Department of Entomology, Ohio State University, Columbus, Ohio.
 S. A. RIFENBURGH, 246 Marsteller St., W. Lafayette, Ind.
 JAMES NEVILLE RONEY, Division Entomology, College Station, Texas.
 MINNIE B. SCOTLAND, 42 Continental Ave., Cohoes, N. Y.
 IVAN SHILLER, 309 Aztec Bldg., San Antonio, Texas.
 ALFRED WEED, 625 Mendota Court, Madison, Wis.

With the approval of the Executive Committee, Dr. Royal N. Chapman was invited to give the annual public address of the Society at the New York meeting. It was also decided to hold a symposium on the subject, "Present Trends in Systematic Entomology."

Wm. Moore, E. P. Felt, F. E. Lutz, W. T. Davis, and H. B. Weiss kindly consented to act as local representatives for the New York meeting.

The Executive Committee met at 4:30 P. M., December 27, in Room 415, Dodge Hall of Teachers College, the following members being present: E. O. Essig, Edith M. Patch, W. D. Funkhouser, H. Osborn, C. H. Kennedy, and J. J. Davis. P. P. Calvert and J. A. G. Rehn, appointed by the president to act for absent members, were also present.

The following Members were elected:

- BERNARD A. APP, 67 N. Liberty St., Elgin, Ill.
 REGINALD E. BALCH, N. Y. State College of Forestry, Syracuse, N. Y.
 OLUS L. BARNES, 362 N. Third Ave., Phoenix, Ariz.
 RALPH E. BARRETT, Department of Entomology, University of California, Berkeley, Calif.
 J. A. BERLEY, Division Entomology, Clemson College, South Carolina.
 IRA WESLEY BERRYHILL, U. S. Department of Agriculture, McAllen, Texas.
 RALPH A. BLANCHARD, 600 Twenty-sixth St., Sacramento, Calif.
 WILLIAM E. BLAUVELT, 214 Thurston Ave., Ithaca, N. Y.
 ARTHUR LOUIS BRODY, Department of Entomology, Cornell University, Ithaca, N. Y.

- FREDERICK MARTIN BROWN, Avon College, Avon, Conn.
M. BRUNSON, Picayune, Miss.
H. G. BUTLER, Entomology Laboratory, Wyoming, Del.
FRANK LESLIE CAMPBELL, Bureau Entomology, U. S. Department of Agriculture, Washington, D. C.
THOMAS P. CASSIDY, Box 1896, Tucson, Ariz.
ANDREW J. CHAPMAN, Tallulah, La.
ARTHUR C. COLE, JR., 2644 Medary Ave., Columbus, Ohio.
CLARENCE ARTHUR CROOKS, P. O. Box 976, Sandusky, Ohio.
S. E. CRUMB, Box 233, Puyallup, Wash.
TRABER NORMAN DOBBINS, Montrose, Miss.
FRED O. DODD, R. R. No. 5, Paris, Ill.
MELVIN HAZELTON DONER, Department of Entomology, University of Wisconsin, Madison, Wis.
NELSON L. DOUGLASS, P. O. Box 613, Grenada, Miss.
WILLIAM ALVIN DOUGLAS, Cut Off, La.
W. E. DOVE, Box 208, Dallas, Texas
WALTER H. DOVE, Department of Entomology, Ohio State University, Columbus, Ohio.
VERDA DOWDLE, Utah Agricultural College, Logan, Utah.
ERASTUS W. DUNNAM, Tallulah, La.
OTIS E. GAHM, 151 W. Eleventh Ave., Columbus, Ohio.
JOHN T. GAMBLE, 118 Shenango St., Greenville Pa.
ROBERT M. GEIST, 811 Euclidean Ave., Columbus, Ohio.
GWYN L. GARRISON, Tallulah, La.
DILLARD WISTER GRIMES, P. O. Box 125, Durant, Miss.
JOSEPH PORTER HARRIS, Union Trust Co., Cleveland, Ohio.
THOMAS VINCENT HENNEBERRY, P. O. Box 976, Sandusky, Ohio.
JENNINGS RUSH HICKMAN, Department of Biology, State Normal College, Ypsilanti, Mich.
NAOMICHI INABA, 207 Harajiku, Sendagayamachi, Tokyo, Japan.
LYDIA A. JAHN, Department of Entomology, Ohio State University, Columbus, Ohio.
LUTHER G. JONES, Drawer 359, Monroe, Mich.
REGINALD MAX JONES, Science Bldg., Ames, Iowa.
WILLARD V. KING, Mound, La.
J. P. KISLANKO, P. O. Box 334, Wiggins, Miss.
JOHN FRANKLIN LAMIMAN, 201 Agr. Hall, University of California, Berkeley, Calif.
HORACE LANCHESTER, 708 E. A St., Moscow, Idaho.
MORTIMER DAMAREST LEONARD, Tobacco By-Products and Chem. Corporation, Louisville, Ky.
HARVEY J. MACALONEY, N. E. Forest Expt. Station, Amherst, Mass.
AUBREY H. MACANDREWS, College of Forestry, Syracuse, N. Y.
GEORGE A. MALONEY, Tallulah, La.
GEORGE E. MARVIN, 1532 University Ave., Madison, Wis.
CHARLES C. B. MAYER, Department of Entomology, Ohio State University, Columbus, Ohio.
DAVID FRANKLIN MILLER, Department of Entomology, Ohio State University, Columbus, Ohio.
CARL OTTO MOHR, State Entomologist's Bldg., Urbana, Ill.
R. W. MORELAND, Tallulah, La.
W. F. MOROFSKY, Department of Entomology, E. Lansing, Mich.
HELEN E. MURPHY, University of New Mexico, Albuquerque, N. M.
RALPH B. NEISWANDER, 713 Center St., Ironton, Ohio.
RICHARD CARL NEWTON, Fernald Hall, M. A. C., Amherst, Mass.
ANDREW R. PARK, JR., State Natural History Survey, Urbana, Ill.
JOHN OSCAR PEPPER, Experiment Station, State College, Pa.
CHARLES CARLTON PLUMMER, Department of Entomology, University of New Hampshire, Durham, N. H.
HAROLD KAUFFMAN PLANK, Trop. Plant Research Found., Cent. Baragua, Prov. Camaguey, Cuba.

WILLIAM PROCTOR, Bar Harbor, Maine.

ARGYLE B. PROPER, 17 E. Highland Ave., Melrose Highlands, Mass.

EDWARD AVERY RICHMOND, 201 Elm Ave., Riverton, N. J.

HERALD K. RIPPY, 27 Russell St., Box 547, West Lafayette, Ind.

RAIFORD A. ROBERTS, P. O. Box 208, Dallas, Texas.

WILLIAM BRICE ROBERTS, 239 S. Fifth Ave., Mt. Vernon, N. Y.

GEORGE SALT, Farnham House Laboratory, Farnham-Royal, Bucks, England.

PAUL DELEON SANDERS, University of Maryland, College Park, Md.

STANLEY SUMPTER SHEFFIELD, A. & M. College, Miss.

LESLIE HAROLD SHROPSHIRE, Fayette, Miss.

EDOUARD HORACE SIEGLER, U. S. Bureau of Entomology, Washington, D. C.

JAY P. SLEESMAN, Department of Entomology, Ohio State University, Columbus, Ohio.

CLIFTON H. SMITH, Hooper, Utah.

GEORGE L. SMITH, Tallulah, La.

H. D. SMITH, European Parasite Laboratory, Domaine du Mont Fenouillet, Hyeres, (Var.), France.

GEORGE EDWARD SPENCER, 36 E. Central Ave., Moorestown, N. J.

A. E. STENE, Bur. Ent., State Department of Agriculture, Kingston, Rhode Island.

W. A. STEVENSON, Box 1896, Tucson, Ariz.

MARSHALL W. STONE, P. O. Box 297, Alhambra, Calif.

WILLIAM ERNEST STONE, Box 549, Sanford, Florida.

CHESTER A. SWINGARD, 467 Blvd. Logan, Utah.

ERNEST ROBERT TINKHAM, Box 242, Presidio, Texas.

LEE HILL TOWNSEND, Department of Entomology, University of Illinois, Urbana, Ill.

GEORGE SHERLOCK TULLOCK, Bussey Institution, Forest Hills, Mass.

MARGARET WINDSOR, 701 Michigan Ave., Urbana, Ill.

DAVID LONZO WRAY, Jr., University of South Carolina, Columbia, S. C.

J. M. YEATES, Tallulah, La.

HIRAM C. YOUNG, Box 1896, Tucson, Ariz.

R. W. HARNED, by payment of \$50.00, was transferred to life membership.

The following members have died during the year:

GUSTAV E. BENDEL, April 2, 1928.

JUAN BRETHES, July 2, 1928.

CHARLES LOUIS FOX, March 1, 1928.

CHARLES W. HOWARD, March 1, 1928.

JACOB KOTINSKY, December 28, 1927.

JEROME MCNEILL, August 30, 1928.

*EUGENE AMANDUS SCHWARZ, October 2, 1928.

The following members resigned during the year:

H. K. Adams, C. K. Arter, L. J. Bottimer, Floyd Brimley, H. F. Carter, R. W. Deveson, F. I. Else, P. B. Fuller, Forrest Garner, Geo. Hofer, A. D. Hopkins, A. J. Kistler, N. W. Lermond, F. C. Nelson, E. J. Oslar, H. E. Roberts, M. G. Rodriguez, Robt. Schmaltz, R. H. Smith, R. D. Spencer. Total 19.

The following persons have been dropped from the Society roll, either because of non-payment of dues for three years or more, or because of failure to reach them:

L. S. Barber, D. M. Bates, J. A. Beal, Samuel Blum, W. W. Bowen, R. B. Cowles, J. C. Crawford, G. M. Decherd, Jr., G. E. Emery, L. V. France, Arthur Frank, C. L. Frankenfield, Lula G. Fritz, J. R. Furr, Horace Gladney, P. A. Glick, G. H. Hammond, C. B. Hardenberg, R. J. Harrington, Paul Herbst, J. D. Humphries, E. H. Ingersol, G. J. Keller, Quinta C. Kessel, Paul Knight, Raoul M. May, J. E. McEvilly, E. A. McMahon, W. M. Morris, T. J. Naude, P. R. Orr,

*Honorary Fellow.

J. T. Potgieter, W. V. Reed, J. A. Reis, Theresa M. Robinson, W. A. Ruffin, Fred Schwarz, H. E. Summers, Cho Teramshi, R. O. Wahl, C. E. White, S. D. Wilcox, Fo Ching Woo. Total 44.

Members.....	741
Fellows.....	92
Honorary Fellows	5

Total Net Membership, December 28, 1928 ..\$38

The following members were elected to fellowship by the Executive Committee:

F. C. Bishopp, R. J. Tillyard, J. R. de la Torre Bueno, H. E. Ewing, A. B. Gahan, Robt. Matheson, H. S. Barber, A. C. Kinsey, H. Morrison, H. H. Knight, Alvah Peterson.

Nathan Banks and E. C. VanDyke were elected members of the Thomas Say Foundation, to succeed themselves.

The following were elected members of the Editorial Board of the ANNALS for the term expiring December, 1931: C. P. Gillette, R. N. Chapman and Franklin Sherman.

The Treasurer reported receipt of \$1,000.00 as a bequeath from the estate of Miss Mary E. Soule, sister of our late member, Caroline E. Soule. The money was transferred to the permanent fund.

Herbert Osborn, editor of the ANNALS since its first issue, offered his resignation and C. H. Kennedy, who has acted as assistant editor for several years, was elected editor.

It was moved and carried that the Executive Committee extend to Professor Osborn a vote of thanks for his long and valuable service as managing editor of the ANNALS and that his name appear on the ANNALS as Editor Emeritus.

Moved and carried that a permanent committee of three, including the Secretary, be appointed by the President, this committee to be known as a committee on co-ordination and to function with a similar committee of the American Association of Economic Entomologists.

Respectfully submitted,

J. J. DAVIS, *Secretary*.

On motion the Secretary's Report was accepted.

REPORT OF THE TREASURER.

CURRENT FUNDS.

RECEIPTS.

Balance, December 28, 1927. (See Annals, XXI, p. 159).....	\$4,333.09
From Annual Dues of Members	2,554.20
From Managing Editor of the Annals.....	700.00
Interest on bonds and savings balance.....	84.67
Total.....	\$7,671.96

EXPENDITURES.

Printing Annals, December, 1926-September, 1928, inclusive, (two years), including separates.....	\$5,259.75
Exchange on Checks	2.55
Printing 1927 Programs.....	29.50
Refund on Checks.....	6.20
Letterheads, Notices, Account Blanks, Envelopes, etc.....	64.34
Clerical Service.....	60.00
International Congress of Entomology.....	150.00
Stamps and Stamped Envelopes.....	45.08

Miscellaneous, Including Telegrams, Refunds, etc	4 09
Total.....	\$5,621 51
Balance, Cash on Hand, Purdue State Bank, December 20, 1928....	2,050 45
	\$7,671 96

LIABILITIES.

The Society owes the publishers of the *Annals* for the December, 1928, issue, and about \$30.00 for programs. Since the books were closed, \$655.53 has been received from the Managing Editor of the *Annals* and at least \$100.00 from members for 1929 dues.

PERMANENT FUND.

The Society holds United States and Canadian Liberty Bonds, total, \$700.00. (See *Annals* XXI, p. 159). Of these, \$350.00 became due and were cashed in December, 1928, this amount being added to the bank account, making a total of \$800.00 in the bank. To this amount has been added \$1,000.00 bequest from the estate of Miss Mary E. Soule and one \$50.00 life membership. The Permanent Fund during the past year has increased from \$1,150.00 to \$2,200.00, an increase of \$1,050.00.

TOTAL RECEIPTS TO PERMANENT FUND.

Liberty Bonds.....	\$ 350 00
Bequest from Estate of Miss Mary E. Soule.....	1,000 00
One Life Membership (R. W. Harned)	50 00
In Purdue State Bank.....	800 00
Total.....	\$2,200 00

Respectfully submitted,

J. J. DAVIS, *Treasurer*.

On motion the Treasurer's Report was accepted, subject to the approval of the Auditing Committee.

REPORT OF THE MANAGING EDITOR OF THE ANNALS.

I have the pleasure of reporting a prosperous year for the *Annals* with the largest volume in its history and I believe a most creditable list of papers. The grant of \$500.00 from the National Academy of Science for publication of research papers, with income from sale of back numbers, has made possible this large volume. Papers now in hand will more than fill the March number and we may expect as large a volume for the coming year.

As this will be the last volume under my charge, it may be permissible after 21 years as Managing Editor to review very briefly the growth of the *Annals*. Starting with a volume of 293 pages in 1908, the growth has been almost unbroken except for a short period during the World War, until we have this year a volume of 700 pages. There has been also a very steady growth in the subscription list, both in member and non-member subscription, and the *Annals* now goes to over 30 different countries, to every state in the United States but one, to Porto Rico, Hawaii, Canal Zone and Philippines, and is to be found in all the principal libraries of the United States and in many other countries.

It is hardly necessary to say that after these years of work with the *Annals* that I cannot escape a feeling of regret in dropping it. It has brought many pleasant associations and I shall remember with much pleasure the host of friendly contacts connected with it. I trust it may be a permanent contribution to entomological science and I feel assured that it will be maintained with increasing excellence as its opportunities widen and its resources continue to grow.

We are indebted this year as heretofore, to many authors for assistance in furnishing illustrations, especially to the Colorado Experiment Station for the beautiful colored plate in No. 1, and to the National Academy for its generous

grant to aid in publication. I am personally much indebted to Doctor Kennedy for assistance in the arduous duties of accounting and mailing.

The financial summary follows:

RECEIPTS.	
Non-member subscriptions	\$ 618 64
From sale of back volumes and numbers	361 82
Engravings and reprints	565 54
Grant from National Academy of Science	500 00
	\$2,046 00
DISBURSEMENTS.	
Mailing charges and postage stamps	\$ 89 79
Stenographic and clerical service	171 00
Engraving bills and incidentals	429 68
Remitted to Treasurer.	1,355 53
	\$2,046 00

Vouchers for the expenditures are submitted herewith.

Respectfully submitted,

HERBERT OSBORN, *Managing Editor.*

On motion the report of the Managing Editor of the Annals was accepted, subject to the approval of the Auditing Committee. A rising vote of thanks was offered Professor Osborn for his long service and loyal support to the Society.

A brief informal report was made by J. M. Aldrich, Editor of the Thomas Say Foundation.

REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION.

FOR THE YEAR 1928.

RECEIPTS.	
Balance on hand January 1, 1928. (See Annals XXI, p. 160)	\$ 21 61
Sale of Vol. I—5 @ \$3.00	15 00
1 @ 3.15	3 15
Received from 1927 sale	3 00
Due on volume delivered, \$3 00.	
Sale of Vol. II—6 @ \$5.00	30 00
5 @ 4.50	22 50
1 @ 5.40	5 40
Received from 1927 sale	14 95
Total Receipts	\$115 61
EXPENDITURES.	
Postage on volumes mailed	\$ 2 98
Stamps	50
Interest on loan of \$400.00, January 1, 1928, December 30, 1928	24 00
Cash to reduce loan	75 00
Balance on hand	13 13
Total	\$115 61

There is a balance due on loan to pay for printing volume II of \$325.00.

Respectfully submitted,

J. J. DAVIS, *Treasurer.*

On motion the report was accepted, subject to the approval of the Auditing Committee.

REPORT OF THE AUDITING COMMITTEE.

We, the Auditing Committee, have examined the books of the Thomas Say Foundation, The Entomological Society of America, and the Managing Editor of the Annals, and have found them to be correct.

Respectfully submitted,

CARL J. DRAKE, *Chairman*,
B. A. PORTER,
J. S. HOUSER.

On motion the report was accepted.

REPORT OF THE RESOLUTIONS COMMITTEE.

Your Committee on Resolutions begs leave to report as follows:

1. That we express our appreciation to the local committees for the New York meetings, especially the local committee for the entomologists, which is composed of Wm. Moore, W. T. Davis, H. B. Weiss, E. P. Felt and F. E. Lutz, for their excellent arrangements, equipment and entertainment provided for this meeting.

2. That the Society has felt a distinct loss in learning of the death during the year of the following members: E. A. Schwarz (Honorary Fellow), G. E. Bensei, Juan Brethes, C. L. Fox, Chas. W. Howard, Jacob Kotinsky, and Jerome McNeill.

3. That the Society desires to thank the National Academy of Science for a grant of \$500.00 for the publication fund for research papers in the Annals of the Entomological Society of America.

4. To express our deep appreciation for the \$1,000.00 presented to the Society from the estate of Mary E. Soule, sister of the late Caroline E. Soule, an honored member of the Entomological Society of America during her life. This is an excellent example which has been set us as entomologists interested in and working for a better Society.

5. That the Society desires to express at this time, on the occasion of the resignation of Dr. Herbert Osborn as Editor of the Annals, its sincere appreciation for his successful and untiring services as Editor, for the past 21 years, of the official publication of the Society, and for the fine progress made in both size and quality of the publication during this time. Further, to express our appreciation to Dr. Clarence H. Kennedy, who now becomes Editor of the Annals, for his faithful assistance to the Editor for the past few years.

Respectfully submitted,

D. M. DELONG, *Chairman*,
J. M. ALDRICH,
P. B. LAWSON.

By vote of the Society the report was accepted.

REPORT OF THE NOMINATING COMMITTEE.

The Nominating Committee beg to report the following names as nominees for the respective offices for the year 1929:

President—C. T. BRUES.

First Vice-President—H. B. HUNGERFORD.

Second Vice-President—LAWSON CAESAR.

Secretary-Treasurer—J. J. DAVIS.

Additional Members of the Executive Committee—For term expiring December 31, 1931—W. T. DAVIS and E. O. ESSIG. For term expiring December 31, 1930, vice C. H. KENNEDY, H. OSBORN.

Councillors to the American Association for the Advancement of Science—W. A. RILEY and C. L. METCALF.

Respectfully submitted,

FRANK E. LUTZ, *Chairman*,
E. P. FELT,
H. OSBORN.

On motion the report was accepted and the Chairman of the Committee instructed to cast a ballot for the election of the persons nominated. This being done, they were declared elected.

The Committee on Collections of Insects in American Museums then reported as follows:

REPORT OF THE COMMITTEE ON COLLECTIONS OF INSECTS IN AMERICAN MUSEUMS.

In continuance of the plan of securing data concerning the progress of the various national and state collections of insects, a request was sent to sixty institutions known to maintain collections, including some such as those at Harvard, Boston Society, Carnegie Museum at Pittsburgh, Field Museum of Chicago, which though not state collections are public in character.

From the replies received the following summary and extracts are presented; it may be noted that a number of reports from collections not hitherto reported are given at greater length and that by referring back to previous reports, (*Annals*, Vol. XX, p. 140, and Vol. XXI, p. 162) one may find quite complete record of the contents of the different collections.

Dr. Aldrich, for the United States National Museum, reports that "The work on the labeling of the Casey Collection of Coleoptera has continued steadily through the past year. Mr. L. L. Buchanan has put half of his time on this project, which is supported by Mrs. Casey. The work is now about three-fourths completed. Several visiting specialists in Coleoptera have made critical examinations of portions of the collection and all expressed high approval of the installation and labeling which have been adopted. Types recorded to date, 6,382.

"The C. F. Baker collection of Philippine and other Oriental insects mentioned last year, was safely received in the National Museum and comprises about 300,000 specimens, being the largest single collection ever received by the Museum.

"The Bureau of Science, through Dr. R. C. McGregor (in the Philippines), also donated to the Museum, in continuance of its policy, a shipment of over 34,000 undetermined Philippine insects.

"Rev. D. C. Graham, of Suifu, Szechuen, China, has continued to collect actively for the Museum and recently sent over 1,700 specimens, bringing his total contribution for the year to 2,572 insects.

"In the fiscal year ending June 30, 1928, one hundred and six papers, by sixty authors, were published, based wholly or in part on National Museum collections. This report also shows a total number of specimens accessioned of 2,698,692, and 42,524 recorded as types."

For the University of Colorado collection, Prof. Cockerell writes: "We have a good collection of fossil insects, with many types, in the University of Colorado Museum. We keep only a general reference collection of recent insects, primarily for class use. All types except bees have been sent away, mainly to the U. S. National Museum. I have in my personal custody a large collection of bees, for use in my work on this group. Many types (especially of *Osmia*, *Halictus*, *Nomada*, and *Megachile*) have been sent to U. S. National Museum. The others will mostly go there eventually, but some (of Australian species) will go to Australia. Types are not loaned."

Mr. Mutchler, for the American Museum of Natural History, says: "Since our last report the following collections containing one thousand or more specimens have been received by the American Museum: The Lewis B. Woodruff collection of about 26,000 specimens of all orders, including his valuable collection of Membracidae, containing most of his type material; Barnum Brown, about 3,500 specimens of all orders from Abyssinia; Whitney South Sea expedition, about 1,000 specimens of all orders from the Solomon Islands; Ladew Expedition, about 1,000 specimens, chiefly Lepidoptera from Bolivia; Frank Johnson, about 1,000 specimens, including many of the rarer forms of Lepidoptera; and a large number of specimens collected by Messrs. Curran and Watson at the Department's Station for the Study of Insects."

For the University of Nebraska, Mr. Swenk says: "In the report of the committee on Collection of Insects in the American Museums for 1926 (Annals Ent. Soc. Amer., XX, p. 146) in the paragraph relating to the University of Nebraska Collections, beginning the seventh line from the bottom of the page, the text should read as follows: 'Bruner's types of exotic *Orthoptera*; Williams, types of Aphididae; Hunter's, Swenk's and Wehr's types of *Diptera*; Dawson's types of Coleoptera; and Crawford's, Swenk's and H. S. Smith's and C. E. Mickel's types of *Aculeate Hymenoptera* are well represented in the collection, which also has numerous types of sawflies described by Rohwer, of bees described by Viereck and of cicadas described by Davis.'

"During the year 1928 Mr. A. F. Satterthwait, of Webster Groves, Missouri, identified the Nebraska Collection of *Calendra*, finding several new species. This collection has been incorporated into the reference series. Also, Mr. P. H. Timberlake, of Riverside, Calif., has furnished through exchange a number of the bee genus *Perdita*, new to Nebraska collection, including paratypes of *P. isolorna*, *P. quadripunctata* and *P. luteipes*. Mr. J. W. Brown has kindly donated paratypes of his *Onihopagus knausi*. Two friends of the Department have donated small but very interesting collections of Philippine and Sumatran butterflies. Mr. O. S. Bare is rearranging the entire collection to conform with the most recent check lists, and transferring the same to new drawers and cabinets."

The California Academy of Sciences replies as follows: "With the exception of a few types, the collection of insects in the California Academy of Sciences was entirely destroyed by the earthquake and fire of 1906. The present collection, therefore, has been accumulated since that time. It now numbers something over 750,000 specimens. The following are some of the principal units of which it is composed: The central collection of the department is a large item and consists of material taken by the present curator and his assistants. Very extensive material presented to the Academy by Dr. E. C. Van Dyke (excepting Coleoptera), by Dr. F. E. Blaisdell, Sr., Mr. C. L. Fox, Mr. L. S. Slevin, Dr. E. H. Nast, Mr. W. M. Giffard, and numerous other friends of the Academy. This unit also includes the insects taken by the Academy's expedition to the Galapagos Islands in 1921, to the islands of the Gulf of California in 1921, to the Revillagigedo Islands in 1925, and to Arizona in 1924. Collections presented to the Academy include the following among the larger units: The W. G. Wright collection of Lepidoptera, including the plesiotypes of his West Coast Butterflies; the J. G. Grundell collection of Lepidoptera, largely exotic; the E. J. Newcomer collection of Lepidoptera, 1,737 specimens; the F. X. Williams collection of Lepidoptera, 7,662 specimens; the W. M. Gifford collection of California Hemiptera, 1,964 specimens; the R. H. Stretch collection of Bombycine moths, 3,146 specimens; the E. C. Van Dyne collection of Chinese insects (excluding Coleoptera), 3,737 specimens; the A. J. Basinger Alaskan collection, 2,210 specimens; the B. Preston Clark collection of Sphingidae from the Hill Museum, 567 specimens; and the Henry M. Holbrook collection of exotic butterflies, 500 specimens. In addition to these, five larger collections have been presented to the Academy that are now being incorporated with the main collection. The estimates for these are well within the probable numbers. These are the E. C. Van Dyne collection of Coleoptera, estimated as 150,000 specimens; the F. E. Blaisdell collection of Coleoptera, estimated at 100,000 specimens, and the L. S. Slevin collection of Coleoptera, estimated as 25,000 specimens. In all these figures mounted material only is

included. The collection of type specimens includes holotypes and allotypes only and numbers 2,468 specimens as far as listed. These types are segregated in special metal cases. E. P. Van Duzee, Curator."

Nathan Banks, for the Museum of Comparative Zoology, reports: "The most important addition is the collection of Diptera of Mr. C. W. Johnson. This contains about 30,000 specimens, over 6,000 species, and 545 types. The far greater part is the U. S. collection, but there is a large European series, considerable amounts from Tropical America, and some from Java, Africa, etc.

"There has also been purchased the Arthur Loveridge collection of English insects, largely Lepidoptera. Dr. W. M. Wheeler has presented his Aculeate Hymenoptera, over 20,000 specimens, largely bees. It is mostly from the United States, but there are some from Central and South America, and Australia. During the year over 30,000 specimens have been added by the mounting of material found last year in storage rooms. The changes to make collections more accessible have been enormous. A hall room was floored over for the entomological library, the third or gallery room is being floored over, electric lights installed throughout, cases were built for 1,200 drawers, 200 new drawers have been delivered, and 1,000 more ordered, new cases for alcoholics and fossil insects also were made, and alcoholic insects are being put in double trays."

The Brooklyn Museum of Arts and Sciences reports: "The reference collection of Lepidoptera, exclusive of Microlepidoptera, is at present contained in 947 drawers. Its composition is as follows: Rhopalocera; Nymphalidae, 9,556; Lemonidae, 652; Lycaenidae, 2,687; Pieridae, 2,562; Papilionidae, 1,794; Hesperidae, 2,524. Total, 19,775. Heterocera Superf. Saturniidae, 1,141; Noctuidae, 17,257; Other families (est.), 28,000. Total, 66,173. There are 322 types among the Noctuidae and approximately the same number in all other groups, making an estimated total of 650. There are very few types among the butterflies. The types, almost exclusively represent North American species. The basis of the collection is the Neumoegen collection, acquired by purchase 1900. To this was added by gift the E. L. Graef collection, a number of smaller collections of more or less value, and the numerous specimens acquired by Museum expeditions to the West and Southwest. The only recent important accession has been the Archibald C. Weeks collection, numbering some 10,000 specimens. A very complete collection of Macrolepidoptera from Long Island, is kept as a separate unit.

The collections of Lepidoptera have been under the care of Jacob Doll from 1897 to 1927, when he retired at the age of eighty. Since then Chas. L. Pollard has been in temporary charge. The Long Island collection has been assembled by Geo. P. Engelhardt. Reference collections other than Lepidoptera are in charge of Chas. Schaeffer since 1902, and their present standing, in large part, represent his efforts in Museum expeditions, local field work and exchanges. Only North American species are included.

Orthoptera	1,400	Specimens,	6	types,	2	paratypes
Neuroptera and Odonata ..	1,200	"	5	"		
Hemiptera-Heteroptera...	2,000	"	6	"	2	paratypes
Diptera	2,200	"	20	"	11	"
Hymenoptera	2,500	"	18	"	4	"
Homoptera	800	"	2	"	12	"
Coleoptera	17,000	"	420	"	9	"
European Coleoptera.....	10,000	"				obtained by purchase

"In addition to the reference collections, The Brooklyn Museum maintains collections for public exhibition dealing with classification and various features in biology, ecology and economics. These exhibits are subject to changes, keeping step with current developments in entomology."

The University of Arizona reports: "A small but steadily increasing collection of insects, chiefly from Arizona. Facilities being somewhat limited and the state very large and of very diverse character, collecting work is being practically confined within state boundaries. The general collection totals at least 15,000 specimens, representing several thousand species, since space does not

permit of large series of duplicates. Specimens are housed in Schmitt boxes and glass top drawers. The order Coleoptera is best represented, by more than 700 species, well classified and arranged. In the Homoptera the collection is good. The family Miridæ is represented by well over 200 species, classified by specialists, and including many paratypes, topotypes, and autotypes. Systematic work on the Coccidæ is being pushed and 119 species have been carefully prepared and classified. In the Hymenoptera the south-western family Mutillidæ is well represented, the species determined by specialists. The Orthoptera number above 1,000 specimens, including more than 100 species determined by specialists. We are anxious to co-operate on any reasonable basis with specialists who will determine material. Charles T. Vorhies, Entomologist."

For Utah, Professor Pack writes: "At the present time this collection includes about 45,000 pinned insects and more than 7,000 slides of soft-bodied insects, mostly aphids.

"The pinned insects are distributed as follows:

	Total	Determined
Orthoptera....	7,000	6,000
Diptera.....	8,526	1,897
Hymenoptera...	8,390	1,624
Coleoptera...	12,418	3,622
Hemiptera...	5,194	813
Homoptera...	1,842	684
Odonata.....	177	0
Neuroptera...	166	8
Plecoptera.....	126	7
Miscellaneous...	1,500	
Total	45,339	14,655

"Included in the Orthoptera is the Henderson collection of nearly 5,000 specimens, most of which are determined, and which includes approximately 300 species. The collection of soft-bodied insects includes 6,500 slides of aphids comprising the Knowlton collection in which are included 400 species. Although most of this collection is made up of Utah material, several hundred slides show aphids from Idaho, northern Arizona, Ohio, Minnesota and other states."

Professor Mote, for the Oregon State Agricultural College, reports: "The insect collection at Corvallis, Oregon, available for use of members of the Entomological Society of America, comprises some 60,000 specimens, mostly in the Orders Diptera, Hymenoptera, Hemiptera, Coleoptera, Lepidoptera and Orthoptera. There are in the collection 2,200 named species and probably 15,000 specimens of Coleoptera, being particularly strong in western species; 450 determined species of Hymenoptera, and 12,000 specimens, many undetermined; 648 determined species and 4,500 specimens of Hemiptera-Homoptera; 794 named species and 8,800 specimens of Diptera, many undetermined; 800 determined species of Lepidoptera, 120 of which are Aegeriidae from all parts of America, Europe, North Africa and Japan, and 15,000 specimens.

"Many of the species collected have not been determined. The collection is not regarded as a museum collection, being rather one of our tools, somewhat like our collection of special literature on entomology and our other laboratory equipment. The foundation of the collection was a set of duplicates sent me from the University of Illinois when I came to this institution in 1889, but most of the species are now represented by Kentucky examples and many others have been added from this State." H. Garman.

T. H. Frison, for Illinois State Natural History Survey, reports: "The insect collection of the Illinois State Natural History Survey has continued to grow as a result of collecting by the survey staff in various localities in all parts of the state. During the past year some 3,000 miscellaneous pinned specimens and 500 vials of specimens preserved in alcohol have been added to the series. In addition, special efforts were made to build up the Illinois series of stone-flies

and plant lice. This resulted in some 5,000 slides of Illinois species of plant lice being made in the field from fresh material and added to the slide series. The collection of stone-flies, particularly the winter species, was practically doubled by the addition of some 2,000 specimens preserved in alcohol."

In Hawaii, "Insects in Bernice P. Bishop Museum are largely from regions in and around the Pacific Ocean. At present the most extensive collections are from Hawaii. These include a portion of the specimens collected by R. C. L. Perkins and described in the 'Fauna Hawaiensis.' Among these are many paratypes. They represent about half the species enumerated in that monograph on the Hawaiian insects. About 25,000 Hawaiian insects of more recent collecting are also mounted and largely identified. There are also specimens from the small outlying islands of the group. A large Samoan collection has recently been worked up in connection with the publishing of 'Insects of Samoa,' by the British Museum. There are a number of specimens from Fiji, New Caledonia, Solomon Islands, New Zealand, Austral Islands, Phoenix Islands, Tokelau Islands, Cook Islands, Society Islands, Palmyra, Fanning, Wake, Guam, and other parts of the Pacific. From Australia there is a large collection, formerly belonging to Richard Helms. This has been augmented by specimens collected by J. F. Illingworth, G. F. Hill, and others. On loan are collections from Australia, Japan, China, Guam, Malay Archipelago, Africa and North America." E. H. Bryan, Jr., Curator of Collections.

Professor Haseman, for the University of Missouri, says: "During the year miscellaneous collecting work had added thousands of specimens to our working collection and during the year we have worked over and entered into the permanent collection a great deal of new material in the orders of Orthoptera and Lepidoptera. We have an excellent working collection primarily for the benefit of under-graduate and graduate students. Our permanent collection is primarily housed in the so-called Comstock cases and it includes 31 cases of named and 17 cases of unnamed Diptera, 36 cases of named and 9 cases of unnamed Orthoptera, 27 cases of named Hemiptera, 19 cases of named and 9 cases of unnamed Homoptera, 49 cases of Coleoptera named and 26 unnamed, 103 cases of named Lepidoptera, 44 cases of unnamed; 11 cases representing Mimicry and 40 cases of strictly educational material, 27 cases of unnamed miscellaneous collections and 20 Schmidt boxes of miscellaneous collections."

The collection of the Department of Economic Entomology of the University of Wisconsin consists of about 75,000 pinned specimens, representing mostly Wisconsin's insects. The majority are named, particularly the Coleoptera, which contains an excellent series of flea beetles, the Lepidoptera, Orthoptera, Diptera, Hemiptera and Homoptera. The collection also contains excellent series of plant material, injured by insects, both dried and preserved in liquid. There are, in addition many vials of alcoholic specimens." C. L. Fluke.

The Cornell collections have been enriched by a collection from Surinam by W. T. M. Forbes and P. P. Babi, and of dragon-flies from China, by Dr. Needham. Other institutions have reported the usual accretions from routine work, or that no outstanding additions have been made.

(Signed) HERBERT OSBORN, *Chairman*,
CHAS. W. JOHNSON,
E. C. VAN DYKE,
J. G. NEEDHAM, *Committee*.

On motion of J. M. Aldrich, it was seconded and carried that, "a permanent committee of three be appointed, this committee to be known as the Historical Committee, the purpose of which shall be to commemorate the American Entomological Pioneers, this committee to have authority to solicit funds for the purpose and shall report annually to the Society."

In addition to the regular program the following exhibits were submitted:

1. Pure Chitin and Some of its Derivatives, by F. LESLIE Campbell, U. S. Bureau of Entomology.
2. Pests Injurious to Cultivated Mushrooms, by CHARLES A. THOMAS, Pennsylvania Agricultural Experiment Station.
3. Tracheations in Newly Hatched Ephemerid Nymphs, by MILDRED C. B. PORTER, Mt. Holyoke College.
4. Mid-Intestinal Gland of a Beetle Larva, by WILLIAM C. WOODS, Kent School.
5. Aleyrodidae of the World, by H. L. DOZIER, Delaware Agricultural Experiment Station.

Fifth Session, Friday Evening, December 28th.

The Annual Public Address was given at this session by Dr. Royal N. Chapman, on the subject, "The Potentialities of Entomology."

Sixth Session, Saturday Evening, December 29th.

The Annual Entomologists' Dinner was held in the Flying Bird Hall of the American Museum of National History.

Respectfully submitted,

J. J. DAVIS, *Secretary*.

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1925	G. A. Dean	L. Caesar	P. S. Welch	C. L. Metcalf	Herbert Osborn
1926	W. A. Riley	C. L. Metcalf	Annette F. Braun..	J. J. Davis	Herbert Osborn
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1928	E. O. Essig.....	Edith M. Patch	W. D. Funkhouser..	J. J. Davis	Herbert Osborn
1929	C. T. Bruces	H. B. Hungerford..	L. Caesar	J. J. Davis	C. H. Kennedy

* Deceased.

ANNALS

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COCOON-MAKING BY THE TARANTULA.*

W. J. BAERG,

Department of Entomology, University of Arkansas.

Cocooning of spiders has been observed and described for various species. H. E. Ewing has published a detailed illustrated account dealing with the house spider. Scheffer has recorded observations dealing with a number of species. Other writers such as Emerton, Savory, Pierre Bonnett, T. H. Montgomery, and others have made contributions to this subject. Regarding the cocoon-making by tarantulas there is, so far as I know, very little in the literature.

The tarantula, *Eurypelma californica* Ausserer, that is common in many parts of Arkansas as well as Texas and New Mexico, mates some time during the latter part of September or during October. In the following summer, from June to August, the females deposit the eggs in cocoons about as large as a black walnut without the hull. The earliest record of a cocoon that I have is June 7. Five cocoons were found to contain 1,018, 930, 787, 693, and 631 eggs respectively.

Although tarantulas do well in captivity (one of mine was taken in the spring of 1919 and as yet shows no decline in vigor), and mate readily during the season; they do not reproduce, presumably for want of some elements in the diet. Thus in order to observe the making of the cocoon, females that were obviously heavy with eggs were brought into the laboratory. During the summer of 1928 I secured two such females and succeeded in observing the entire process. When the

* Research Paper No. 134, Journal Series, University of Arkansas.

first female put on her performance I did not dare to take any pictures because of the inevitable disturbance that would accompany it. The second female was placed in a fairly large battery jar, seven-and-a-half inches in diameter, containing a layer of dirt covered over with fine black cinders. When she proceeded to make the cocoon, her amiable disposition made possible a number of time exposures, six of which are used to illustrate this paper.

Tarantula No. 1 was in a battery jar six inches in diameter and nine inches deep, containing one or two inches of soil. On June 30 she began spinning at about 7:45 A. M. At first she left a bare area on which she stood and spun all around herself. Then she began to move about and covered half of the soil surface as well as the wall to a height of about four inches. The finished product was a good-looking cradle, stretched over half of the soil, sloping up at the ends and equipped with a wall, about one-fourth inch high, along the straight side. This wall, as soon became evident, was intended to hold the egg mass more or less together.

In making this cradle, the tarantula worked very steadily, moving the abdomen from side to side so that the spinnerets would go from under one hind leg to under the other hind leg. In going over this stretch, approximately three inches, the spinnerets would touch the base about four times. When working on the sides she would stand nearly erect on her front legs, reaching about four inches up on the wall. She would rest every three or five minutes, but only for a very short period, from five to ten seconds. When the cradle was nearly done the rests became somewhat longer.

At 5:15, i. e. after nine-and-a-half hours of spinning, she considered the task finished. Assuming a position in which the abdomen was practically resting on the sheet of silk, and the anterior part of the cephalothorax well above it, she proceeded to deposit the eggs. These were in a liquid that gave the mass a light yellowish color. Egg laying required seventeen minutes. Unfortunately the wall that was to retain the eggs failed to do so, a part of the egg mass overflowed and became quite puzzling to the tarantula.

Immediately after egg-laying was finished she proceeded to cover the eggs with another layer of silk. For a time she spun mostly over the eggs, but later she spun over almost the entire

cradle. After spinning steadily for two hours and two minutes, allowing only short rests, as before; she began to pull down one end of the sheet, and then began to spin again. This alternating of spinning and tearing down (a sort of dove-tailing of the two phases in the performance) went on for an hour and twenty-three minutes.

Then the tarantula proceeded to pull the sheet from off the wall of the jar, using her palpi as well as the fangs. When the sheet was completely on the soil, she pulled up and back the edges and pressed them down with the weight of her body. Finally this was but a turning over on the edge and pressing down of the silken bag. In this part of the performance the tarantula became very deliberate, at first she would spend from twenty to thirty seconds resting on the cocoon, then longer, so that by 11:00 P. M. she spent from three to five minutes resting on the cocoon after turning it.

Tarantula No. 2 made her cocoon on July 8. When first observed, 8:15 A. M. she had almost finished the cradle, having presumably begun it about midnight. Egg-laying began at 8:17 and was finished in fifteen minutes. For an hour and forty-eight minutes she spun over the eggs and the cradle; an hour and twelve minutes was devoted in part to spinning and in part to pulling down the sheet. At 12:06 she proceeded in earnest with the shaping of the cocoon. She behaved in this just as already described for Tarantula No. 1. At 4:30 when I left her, she was devoting almost all the time to resting on the cocoon.

Tarantula No. 2 differed from No. 1 in that she made somewhat more rapid progress in the spinning. A more important difference was that instead of building a low silken wall she threw up a low earthen barrier, about one-fourth inch high, and about an inch wide. It answered the purpose well for the egg mass remained in the space intended for it (see Plate I).

The cocoons made in the laboratory jars are not as well constructed as the ones found out of doors. Some of these are apparently made under stones where the tarantula digs out a cavity sufficiently large for such operations. Many of the cocoons are apparently made in holes in which the tarantulas live. How they are able to do this in a space no larger than about one-and-a-half inches in diameter is not easily understood. It is possible that before making the cocoon the taran-

tula enlarges the base of her burrow, but I have seen no evidence of this.

After the cocoon has been made the tarantula stands guard over it, and on sunny days rolls it to the entrance of the burrow. From numerous failures in the laboratory, I have learned that the eggs require a good deal of sunlight. It seems that too much sunlight, or perhaps heat, will also prevent hatching.

At the end of a rainy and cool summer, I found several cocoons near tarantula holes that had apparently been abandoned by their owners. Presumably the cool and cloudy weather had delayed emergence of the spiders so long that the mothers had abandoned all hope. Two of these when taken in later produced a large number of young.

Since the young after hatching remain in the cocoon for some time, till they are ready to go through the first molt, the time required for hatching is not easily determined. And since cocoons made in the laboratory, or brought in when but very recently made, fail to produce any young; the time required for hatching and completion of the first instar can be no more than estimated. The earliest emergence observed is July 31, and the latest September 4. A cocoon brought in on July 27 produced young on September 4.

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Above: Just before egg-laying. Note distended abdomen.
Below: Egg mass. Note much reduced abdomen.



Above: Starting to tear down cradle. No trace can be seen of egg mass.
Below: A later stage in tearing down.



Above: Cocoon has begun to take shape.

Below: Cocoon about finished, fore legs raised in attitude of defense. Note this silken strand allowed to remain, as a guide to locate cocoon.

VARIATION AND CORRELATION ON THE LEGS OF THE HONEYBEE.

V. S. DAKESSIAN.

Although much work has been done on the variability of the different appendages of the honeybee and other social insects, within the last few years Russian investigators have revived special interest in this work from a somewhat different angle with different races of bees of different localities in Russia, and more recently in other countries of Europe and this country.

Works of Casteel and Phillips (1903), Kellogg and Bell (1904), Bachmetjew (1909), and many others, and recently of Phillips (1928), are chiefly on the variability of the different parts of the wings of different castes of the honeybee. The work of Russians, especially those of Alpatov (1925) and Alpatov and Tjunin (1925) are chiefly devoted to the difference in length and variability of the tongues of honeybees of different races and from different localities. Some of the works of Alpatov have been published and others are in process of publication, while still others are in preparation. It is unnecessary to review the literature on this subject here, since Phillips (1928), under whose direction this work was done, has prepared a paper on "The Variation and Correlation in the Appendages of the Honeybee" where extensive literature has been cited and reviewed. This work of Doctor Phillips will be published as a Memoir at the Cornell University Agricultural Experiment Station.

The legs of the honeybee, especially those of the workers are highly specialized for use of various functions other than locomotion. Without going into the details of the functions of different legs it may be said that little, if any, work has been done on the variation and correlation in the different segments of the legs of the honeybee. This work was therefore done in order to determine the variations and such correlations as may exist and to throw some light on the growth of the various parts of the legs in their relation to each other. The writer wishes to express his thanks to Dr. E. F. Phillips for his permission to use his manuscript and for his encouragement

at the beginning of the work, and also to Professor W. W. Alpatov for his valuable suggestions in preparing the legs for measurement.

Source of Material.—The individuals used in this work were taken from one colony of Italian bees in the apiary of Cornell University, at the middle of the day on July 6, 1927, and included both young and old bees. No drones were included and nothing was specifically known of the history of the colony from which the bees were taken at random.

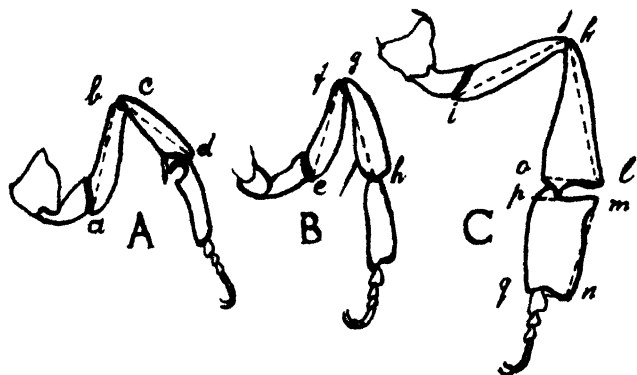


Fig. 1 Legs of the honeybee. Dotted lines show the points and the direction of the measurements.

Methods and Measurements.—The legs of bees are covered with heavy hairs and all the joints of the leg are heavily pigmented which makes accurate measurements difficult. To overcome this difficulty the bees were boiled in caustic potash until sufficient decoloration took place to make the distinction of definite points on the segments possible and to clarify the places where measurements could be made. While decoloring, it was noticed that the color of the upper segments of the legs, the coxa and trochanter, were much more heavily pigmented than the distal segments. Because of this and because of the irregularities of these segments no measurements were made of the coxa and trochanter. It was also noticed that the first and second legs are more heavily pigmented than the third legs, the tarsal segments of the third legs being least heavily pigmented and most easily bleached.

The points where the measurements were made on different legs are shown in Fig. 1. The measurements made on the

first, A, legs are only femur *a-b*, and tibia *c-d*. On the second, B, legs also femur *e-f* and tibia *g-h*. The first tarsal joints of these legs are covered with heavy hairs, and the tibia overlapping the first tarsal joint makes accurate measurement impossible. The measurements made on the third C, legs are the femur *i-j*, tibia *k-l*, the first tarsal segment *m-n*, the lower width of the tibia *o-l*, the upper *p-m* and the lower *q-n* width of the first tarsal segment.

The bees were preserved in 95% alcohol and those to be mounted were first brought to tap water and then mounted on slides in glycerin. This method saves considerable time and can be recommended for temporary work.

The legs of each bee were mounted separately and numbered in order to make correlations possible and to note the individual variations and the correlations that may exist between the segments of the legs of the same bee.

The method of measurement is partly that described by Phillips (1928). In order to reduce inaccuracies the microscope and the camera lucida were so arranged as to give a magnification of 50 diameters at table level. The ocular and the objective remained unchanged throughout the work and the tube of the microscope was fastened securely to prevent change. At the beginning it was found that the point and the direction of the measurement made on the reflected field made considerable difference in measurements. In order to avoid this inaccuracy, all measurements were made from one point on a straight line. The one end of the segment to be measured was brought to a definite point and the other end on the same straight line on which the fixed point was marked. Measurements were made on 200 individuals. All calculations were made by the usual biometric methods.

Variations.—From the data presented in Table I it is seen that the variation of the means, standard deviation and coefficient of variability of the bilateral symmetries is insignificant, in most cases being less than the probable error. This indicates that the size of the symmetrical segments are almost identical.

The coefficient of variability of the different segments are rather interesting. In all cases, except those of the width measurements, the coefficient of variability is smaller in the legs than in the other appendages except the tongue length, and

length and width of the head of which extensive data from different sources are given by Phillips (1928, Tables VIII, X and XI). Phillips finds similar variation in the vein *m* (right 2.5939 ± 0.055 ; left 2.5734 ± 0.055) of the worker as it is found in the first tarsus of the third legs (right $2.5218 \pm .0850$, left $2.5927 \pm .0874$). For the same segment of the larger drones, Phillips finds $3.8412 \pm .082$ variation. This points out the accuracy of the conclusion reached by the same

TABLE I.
THE VARIABILITY OF PARTS MEASURED.

CHARACTERS	MEAN $\times 50$	STANDARD DEVIATION	COEFFICIENT OF VARIATION
1st tarsal joint, left 3rd leg	106 040 $\pm$ 1311	2 7493 $\pm$ 0927	2 5927 $\pm$ 0874
1st tarsal joint, right 3rd leg	106 085 $\pm$ 1276	2 6752 $\pm$ 0902	2 5218 $\pm$.0850
Tibia, left 3rd leg	172 620 $\pm$ 1378	2 8889 $\pm$ 0974	1 6736 $\pm$ 0564
Tibia, right 3rd leg	172 710 $\pm$ 0144	3 0110 $\pm$ 1015	1 7434 $\pm$ 0588
Femur, left 3rd leg	142 805 $\pm$ 1215	2 5470 $\pm$ 0859	1 7836 $\pm$ 0602
Femur, right 3rd leg	142 850 $\pm$ 1155	2 4223 $\pm$ 0817	1 6927 $\pm$ 0572
Tibia, left 2nd leg	108 450 $\pm$ 1085	2 2754 $\pm$ 0767	2 0981 $\pm$ 0708
Tibia, right 2nd leg	108 395 $\pm$ 1140	2 3914 $\pm$ 0806	2 2062 $\pm$ 0744
Femur, left 2nd leg	123 060 $\pm$ 1228	2 5742 $\pm$ 0868	2 0918 $\pm$ 0705
Femur, right 2nd leg	122 810 $\pm$ 1281	2 6859 $\pm$ 0906	2 1870 $\pm$ 0738
Tibia, left 1st leg	96 270 $\pm$ 1046	2 1925 $\pm$ 0739	2 2774 $\pm$ 0768
Tibia, right 1st leg	96 075 $\pm$ 1048	2 1976 $\pm$ 0741	2 2714 $\pm$ 0766
Femur, left 1st leg	114 410 $\pm$ 1108	2 3242 $\pm$ 0784	2 0315 $\pm$ 0685
Femur, right 1st leg	114 435 $\pm$ 1159	2 4302 $\pm$ 0820	2 1237 $\pm$ 0716
Lower width, 1st tarsal joint, left 3rd leg	35 540 $\pm$ 0721	1 1527 $\pm$ 0510	4 2563 $\pm$ 1435
Upper width, 1st tarsal joint, left 3rd leg	58 045 $\pm$ 0935	1 9604 $\pm$ 0661	3 3774 $\pm$ 1139
Lower width Tibia, left 3rd leg	68 530 $\pm$ 0999	2 0950 $\pm$ 0707	3 4611 $\pm$ 1167

and other authors that drones are more variable than the workers.

Among the different segments of the legs the femur and tibia of the third legs are less variable, the degree of variability being similar to those of the variability of the tongues of Tula bees, which seem to be the least variable, (Phillips 1928, Table VIII) and those of the width of head of bees of various races (Phillips 1928, Table X). The variability of the similar segments of the other legs are somewhat greater than those of the third legs with rather insignificant difference in all cases.

Among the segments measured, the first tarsal joints of the third legs show greater variability. It is interesting to note that the segments vary more in their width than in their length.

Schneider and Dunn (1924) find about three times more variation in the tibia ($4.398 \pm .113$) and femur ($4.326 \pm .112$) of the White Leghorn fowl than it is found in the tibia and femur of the bee. Castle (1916) finds 2.524 coefficient of variability in inbred race B. guinea-pigs.

Correlation.—In Table II are given the values of the coefficient of correlations between different segments. In all cases correlations between symmetrical segments are higher than those between non-symmetrical segments. Similar correlation is found by Phillips (1928) for other parts of the honeybee, by Clawson (1905) in crayfish, by Lewenz and Whitely (1901-1902) in the hands of men. The highest correlation is found between the first tarsal segment of the third legs $.9486 \pm .0048$. On the same legs the correlation between the tibia $.9404 \pm .0055$ is slightly greater than between the femur $.9256 \pm .0068$. In all cases however, the difference is insignificant. The reverse is true for the first and second legs where the correlation is higher between the femur than it is between the tibia.

The correlation between the first tarsal joint and the tibia of the third leg is greater ($.7391 \pm .0216$) than that between the first tarsal joint and femur of the same leg. This brings out the conclusion arrived by Lewenz and Whitely that "There is 'rule of neighborhood,' i. e., any bone is more closely correlated with a second of the same series than with any other from which it is separated by that second."

The correlation between the femur of the first legs and between the femur of the second legs is almost identical ($.8652 \pm .0120$ and $.8622 \pm .0122$ respectively). However, the correlation between the tibia of the second legs is somewhat greater ($.8054 \pm .0168$) than between the tibia of the first legs ($.7897 \pm .0180$).

The correlation between the tibia and femur of symmetrical legs is greater on the third leg ($.7333 \pm .0220$) than it is on the other two pairs of legs, it being slightly larger in the first leg ($.6327 \pm .0286$) than in the second leg ($.6040 \pm .0303$).

Castle (1914) finds greater correlation (.858) between the femur and tibia of rabbits than is found in the honeybee. In a later work (1922) again on rabbits he finds still greater

correlation ($.927 \pm .005$). Schneider and Dunn (1924) also find greater correlation ($.928 \pm .005$), their figures being identical with Castle's later work (1922).

The tibia of the third leg shows greater correlation with the tibia of the second leg ($.5235 \pm .0346$) than it shows with the tibia of the first leg ($.4898 \pm .0363$). The same is true for the femur of the third leg with the femur of the first and second

TABLE II.
CORRELATION BETWEEN THE VARIOUS SEGMENTS MEASURED.

CHARACTERS	COEFFICIENT OF CORRELATION
Bilateral symmetry, 1st tarsal joint, 3rd leg	$.9486 \pm .0048$
1st tarsal joint and tibia, left 3rd leg	$.7391 \pm .0216$
1st tarsal joint and femur, left 3rd leg	$.6373 \pm .0283$
Length and lower width, 1st tarsal joint, left 3rd leg	$.0621 \pm .0475$
Length and upper width, 1st tarsal joint, left 3rd leg	$.2409 \pm .0449$
Bilateral symmetry, tibia, 3rd leg	$.9404 \pm .0055$
Tibia and femur, 3rd left leg	$.7333 \pm .0220$
Tibia and lower width, 3rd left leg	$.3844 \pm .0406$
Tibia, left 3rd leg, tibia, left 2nd leg	$.5235 \pm .0346$
Tibia, left 3rd leg, tibia, left 1st leg	$.4898 \pm .0363$
Bilateral symmetry, femur, 3rd leg	$.9256 \pm .0068$
Femur, left 3rd leg, tibia, left 2nd leg	$.7369 \pm .0218$
Femur, left 3rd leg, tibia, left 1st leg	$.6656 \pm .0266$
Bilateral symmetry, tibia, 2nd leg	$.8054 \pm .0168$
Tibia, left 2nd leg, tibia, left 1st leg	$.6973 \pm .0245$
Tibia and femur, left 2nd leg	$.6040 \pm .0303$
Bilateral symmetry, femur, 2nd leg	$.8622 \pm .0122$
Femur, left 2nd leg, femur, left 1st leg	$.7163 \pm .0232$
Bilateral symmetry, tibia, 1st leg	$.7897 \pm .0180$
Tibia and femur, left 1st leg	$.6327 \pm .0286$
Bilateral symmetry, femur, 1st leg	$.8652 \pm .0120$

legs, but the correlation is higher between the femur of different legs than it is between the tibia of the same legs.

It is rather interesting to note the correlation between the length and the width of the segments. The correlation between the length of first tarsal joint of the hind leg and the lower width of the same joint is only $.0621 \pm .0475$, almost equal to its probable error. Of the upper width it is $.2409 \pm .0449$. The correlation between the length of the tibia and lower width of the same joint of the third leg is only $.3844 \pm .0406$, indicating that there is little correlation between the width and length of the segments, and that it is insignificant.

Conclusion.—Considering first the variability of the different segments of the different legs of the honeybee it is found that the first tarsal joint of the third leg is more variable than any of the other joints. The least variable segments are the tibia and femur of the third leg. The variability of the femur and tibia of the first and second legs are almost the same. The width of the segments measured are more variable than the length of any segment.

The variability of the segments of the legs of the honeybee is less than the variability of the different parts of the wing and still less than it is found in the leg joints of other animals.

The highest correlation is found between the bilaterally symmetrical joints. Taking each separately, the correlation between the segments of the third legs is higher than between the similar segments of the first and second legs.

Correlation between the segments of one leg is higher than the correlation between the similar segments of different legs.

There is no correlation between the length and width of the same segments.

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ON A COLLECTION OF GRYLLACRIDS AND TETTIGONIIDS (ORTHOPTERA), CHIEFLY JAVANESE.

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Some of the determinations in a recent paper* appeared to me as somewhat doubtful, apparently due to insufficient material for comparison. Being especially interested in the two groups here treated, having worked on the Malayan forms of them for seven years and studied the types of most of the described species in European collections, I wrote to the author of the paper, who kindly loaned me the material discussed in the present article.

Family GRYLLACRIDÆ.

As I have shown in 1910 (SCHULTZE, Zool. Anthrop. Ergeb. Forsch. westl. u. zentr. Sudafrika; IV, 1, p. 35), it is quite impossible to retain the "Stenopelmatidæ" and "Gryllacridæ" of BRUNNER as mere subfamilies of Tettigoniidæ, and they must constitute together a separate family, the Gryllacridæ (s. l.), which must be regarded of the same rank as the Tettigoniidæ. A. GRIFFINI, the only specialist of Gryllacridæ at that time, has accepted entirely my point of view, when he says (Riv. mens. Sci. Nat. "Natura," II, p. 29; 1911): "Invece gli Stenopelmatidi vanno piuttosto uniti ai Grillacridi che sono le forme maggiormente primitive degli Ortoteri Saltatori, ed i Grillidi sono piu prossimi a questi che non gli altri gruppi." Nevertheless, most of recent authors have retained them as subfamilies of Tettigoniids, without giving any reason for not accepting GRIFFINI's and my system. I must suppose, therefore, they have apparently overlooked the literature cited above.

*1927. Caudell, A. N. Proc. U. S. Nat. Museum, Vol. LXXI, Article 3; 42 pages, 4 figs.

Subfamily GRYLLACRINÆ.

Gryllacris africana Brunner v. W.

1 ♂, Togo, Misahohe, 1894, E. BAUMANN S.—1 ♀, S. Kamerun, Lolodorf, L. CONRADT S.

Both specimens in every respect quite typical. Venation, type I, as described for this species in my revision of the Gryllacrids of Vienna Museum (now in press). Only a few aberrations in the number of branches may be noticed, viz.: Right tegmen of ♀ with six precostals. Radial vein on right tegmen of ♂ divided apically into five branches. On left tegmen of ♀ the posterior branch of the cubitus is forked,

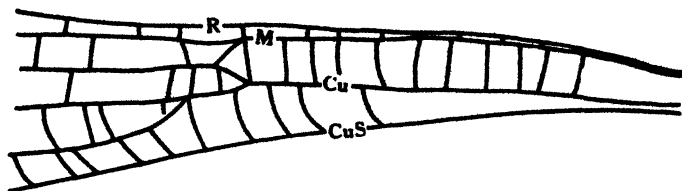


FIG. 1. *Gryllacris africana*, ♀. Basal area of left tegmen.

instead of the fore branch, which remains simple throughout on this tegmen (Fig. 1). Right hind wing of ♀ with radial vein five-branched.

Gryllacris translucens Serville.

1839. SERVILLE, Hist. Nat. Ins. Orth., p. 394, (*translucens*), (Java).
 1860. GERSTAECKER, Arch. f. Nat., xxvi, p. 271, (*amplipennis*), (Brit. India).
 1922. HEBARD, Proc. Ac. Nat. Sci. Philad., lxxiv, p. 276 (*vitrea*), (Borneo).
 1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 28, (*tibialis*, nec SERVILLE), (Java).

Though I have not seen HEBARD's type specimen of his *vitrea*, there can be no doubt from his accurate description that *vitrea* must be regarded as a synonym of *translucens*. This species was not yet recorded from Borneo, but I have seen in the Vienna Museum Bornean specimens which agree in every respect fully with the Javanese ones.

The specimens mentioned by CAUDELL as *tibialis* are now before me. They are typical *translucens* without any black color on tibiae. *Gr. tibialis* does not occur in Western Java, so far as known; at least, in the neighborhood of Buitenzorg, I could never get that species amongst some hundreds *Gryllacris* specimens, whilst it is quite common in Central Java.

1 ♂, Mt. Salak, Java, BRYANT & PALMER Coll.—1 ♀, same collectors, Buitenzorg, Java, iv, '09.—1 juv. ♀, same collectors and locality, iii, '09.—1 juv. ♀, Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD.

All specimens quite normal and typical. The juv. ♀ from BRYANT & PALMER Coll. resembles, however, by the shape of ovipositor a fully-grown *Neanias*; the ovipositor being strongly curved, but not upwards and forwards against the abdominal tergites as usual in immature specimens, but the distal portion directed upwards and backwards. Nevertheless, there can be no doubt that it belongs also to *translucens*, as the larval wing-pads are very distinct, even longer than the pronotum.

Venation of the adult specimens quite normal. Type I, Radial vein of tegmina four- to seven-branched. On right tegmen of the ♂ before me the fore branch of the cubital vein is simple, whilst the hind branch is furcate; this represents, therefore, the same abnormality as figured above for *africana* (Fig. 1), but the bifurcation of hind branch placed somewhat more distad in *translucens* than in *africana*. Radial sector of hind wing three-branched.

***Gryllacris melanocrania* n. sp.** (Plate I, Fig. 1)

1 ♂ (Holotype), Mokanshan, China, from N. GIST GEE.
1 ♀ (Allotype), Soochow, China, N. GIST GEE coll.

	Length of Body	Pron.	Tegmen	Fore Fem.	Hind Fem.	Occipos.
♂	24.5 mm.	6.5 mm.	29 mm.	9.4 mm.	17 mm.	
♀	27 mm.	7.3 mm.	30 mm.	11.3 mm.	19.5 mm.	25 mm.

Quite near to *Gr. humberti* GRIFFINI and *nigromarginata* KARNY, in size, agreeing better with the latter than with the former. General color cinnamon-buff, with head partly black and pronotum black margined.

Head a little wider than pronotum, subglobose. Occiput, vertex (excl. fastigium verticis), genæ, mandibles and labrum (excl. its extreme basal part) shining black, this color overreaching in front subocular sulci a little mesad. A narrow median line on occiput and its hind margin of body color. No ocellar spots. Antennal scrobes not margined with black. Basal segment of antenna strongly darkened, the following ones shining black, from about the 10th to 15th becoming gradually paler, rest of antennæ of body color. Suture between fastigium verticis and frontis concolorous, not at all blackish. Eyes yellowish or reddish brown.

Color of pronotum quite as in *nigromarginata*, but no median pale length line on metazona. Fore margin of the disc a very little produced in the middle. Median sulcus of mesozona very feeble, metazona with a slight median keel.

Tegmina: Three simple precostals (σ) or the last bifurcate near base ($\varnothing$). Costal vein simple ($\varnothing$) or with two oblique anterior branches (σ), reaching the fore margin somewhat before ($\varnothing$) or behind the apical third. Radial vein three-branched before the end, the branches oblique, distant from another (Fig. 2). Radial sector arising from radial stem before the middle, four-branched. Medial vein with a short, oblique cross vein against the cubital fore-branch near its base, otherwise simple. Cubital vein free, bifurcate at about the end of basal third. (Hind wings not expanded in the specimens before me, greyish hyaline with dark veins).

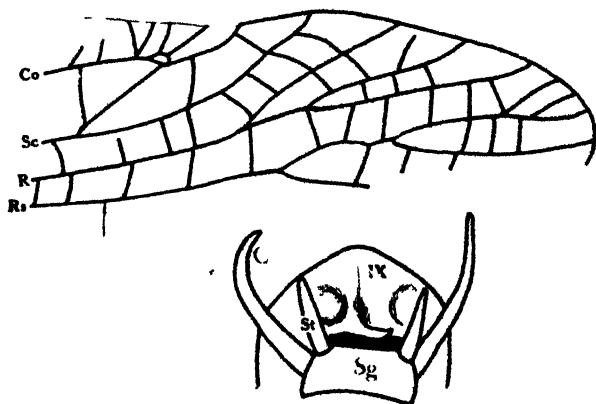


FIG. 2. *Gryllacris melocrania*, σ Holotype. Preapical portion of right tegmen (above), and end of abdomen, ventral view (below).

Meso- and metapleuræ concolorous, without black stripes. Knees not at all darkened. Legs concolorous, except all the spines being black, those of hind legs surrounded at base by a black spot. Apical spurs pale, those of hind tibiae black-tipped. Hind femora on outer ventral margin with 6 spines, the inner margin with a dozen or more spines, the basal ones of the latter very small. Hind tibiae above on either side six-spined, only the right one of $\varnothing$ seven-spined on the outer side.

Abdominal segments concolorous in $\varnothing$, partly blackish at base in σ . Penultimate tergite of σ pale, only somewhat darkened along hind margin; σ subgenital plate with hind margin truncate, transverse, quite straight. Styles well developed, longer than subgenital plate, (Fig. 2).

Ovipositor straight throughout, by one-fourth longer than the hind femora, rather pointed at the tip; $\varnothing$ subgenital plate quite as in *humberti*, but the basal arcuate keels not black.

All other characters not mentioned in the description above much as in *nigromarginata*.

Differing from both *humberti* and *nigromarginata* at first view by the black occiput and genæ and by the quite concolorous knees of all legs. From *humberti*, moreover, by much smaller size and relatively much longer ovipositor. From *nigromarginata* by the shape of ♂ subgenital plate and much longer styles (♀ of *nigromarginata* not yet known). There are also some differences in tegminal venation, (See Fig. 2).

Type and Allotype in U. S. National Museum. Catalog No. 41225.

Gryllacris fuscinervis var. **evanida** nov. (Plate I, Figs. 1, 3, 5, 6).

The following synonymy of the typical form was established by GRIFFINI in 1913, (Ann. Mus. Nat. Hungar., xi, p. 304).

1877. STAL, Oefv.-Vet. Ak. Forh., 9, p. 47 (*fuscinervis*).

1904. NAVAS, Bolet. Socied. Aragon. Ci. Nat. Zaragoza, III, 5-6, p. 5, (*scripta*).

1 ♂ (Holotype), 1 ♀ (Allotype). Govt. Lab. Coll., Acc. No. 1004 (without locality). 1 ♂, 1 ♀ (Paratypes), Malabang, Mind., P. I., J. M. T. PARTELLO coll.

In general aspect somewhat resembling *inconspicua*, but with a quite different tegminal venation, being of type III, while *inconspicua* is of type V b.

I name these specimens var. *evanida*, because they have less extended black signs on head and pronotum than the typical *fuscinervis*. Thus they are somewhat intermediate between *fuscinervis* and *brachyptera*, and there can be no doubt that these two Philippine species are quite nearly related, and it is not impossible that they may be nothing else than mere color variations of the same species. At all events, we may state the following series of increasing melanisme: *brachyptera*, *fuscinervis*, *evanida*, *fuscinervis*, *fuscinervis panayensis*, *fuscinervis diamantii*.

The coloration of the specimens now before me is as follows:

♂, Holotype: (Plate I, Fig. 1).—Occiput pale, on either side with a broad, oblique blackish stripe converging forwards and meeting with another on fastigium verticis, which is blackish with a few pale spots and pale margined below and on either side. Eyes dark; antennæ pale throughout. Just below the suture between fastigium verticis and frontis, on either side, a small dark spot. Frons with a vertical dark stripe beginning at the inner lower angle of antennal scrobes and gradually vanishing downwards. Pronotum infuscated along hind margin of the disc and at the hind angle of lateral lobes, with a well-

defined *signifera*-like design on the disc and a dark longitudinal spot on either side of metazona. Fore femora very slightly infumate before the knee; fore and middle tibiae with a diffuse grey spot below the knee, and with long, pale, movable spines. Hind knees slightly darkened, the extreme tip of hind femora pale, spines of hind legs blackish. Last abdominal tergite somewhat infumate, sternites with two longitudinal rows of large, dark spots.

♀, Allotype: (Plate I, Fig. 3).—Head practically as in the holotype, but broader and less well-defined. The frontal stripes diffuse, occupying nearly the whole breadth of antennal scrobes, reaching downwards to clypeal suture. Dark designs of pronotum arranged practically as in holotype, but slighter and less well-defined. All femora strongly infuscated on either side of distal portion, pale above. All tibiae dark brown above nearly throughout their whole length. Sternites as in holotype, ovipositor pale.

♂, Paratype: (Plate I, Fig. 5).—Occiput pale brownish. Fastigium verticis pale. Antennal scrobes black margined. First and second segments of antenna blackish at base and at apex. The frontal black stripes confused with another in the middle of forehead, and with the two upper spots (thus surrounding the lower ocellar spot with black), extending downwards to the upper part of clypeus. Pronotum yellowish brown, not conspicuously darkened along hind margin, somewhat infuscate near the hind angle of lateral lobes; disc uniformly colored except a well-defined 7-shaped stripe on either side of the middle. Femora not darkened; tibiae shining black, except in the apical fourth or fifth.

♀, Paratype: (Plate I, Fig. 6).—Head pale, forehead with both fastigium frontis and verticis blackish. Three ocellar spots yellowish, sublinear, well-defined. Pronotum practically unicolorous, ferruginous. Legs as in ♂ paratype.

	Length of Body	Pron.	Tegmen	Fore Fem.	Hind Fem.	Ovipos.
♂, Hol.	19'3 mm.	5'2 mm.	17'7 mm.	7'3 mm.	13'5 mm.	
♀, All	18'5 mm.	5'5 mm.	17'2 mm.	8 mm.	14'5 mm.	13'8 mm.
♂, Par . . .	19'7 mm.	5 mm.	16'4 mm.	7'2 mm.	12'8 mm.	
♀, Par . . .	≈18 mm.	5'7 mm.	16 mm.	6'7 mm.	13'2 mm.	13'2 mm.

Sexual characters and venation practically as in *brachyptera* (comp. Phil. Journ. Sci., xxviii, 1, p. 142-144; Plate 3, Fig. 8; Plate 7, Figs. 3, 4; Plate 8, Figs. 1-3).

Tegmina: Two to four precostals, all simple or one of them forked; the last one may arise from costal base. Costal vein simple, reaching fore margin about at the end of middle fifth. Costal area strongly dilated, broadest at about its middle, it extends to the end of basal third of tegmina. Subcostal vein arising from tegminal base, basad straight, then curved forwards, usually with a long apical fork, sometimes simple throughout, in the left tegmen of ♂ paratype four-branched, (Fig. 3 above). Radial vein divided in apical part into three to four oblique, distant branches, (Fig. 3, below), sometimes forked or even simple, on the left tegmen of ♂ paratype emitting only a very

short anterior branch into the last subcostal branch, (Fig. 3 above). Radial sector arising from radial stem usually about in the middle, sometimes more distad, just after the first radial branch (like Phil. J. l. c. Plate 7, Fig. 3); in distal part simply forked or three-branched. Medial free from base, bifurcate about at the end of second fifth, both branches usually remaining simple, sometimes the hind branch forked again a rather short distance before apical margin (Fig. 3 above); on right tegmen of holotype the hind branch not reaching apical margin, but the fore branch, on the other hand, bifurcate again at the end of middle fifth. Cubital vein free, simple, S-shaped. Behind it, follow five simple, free longitudinal veins, only on both tegmina of holotype, the last of them strongly reduced, weak and short.

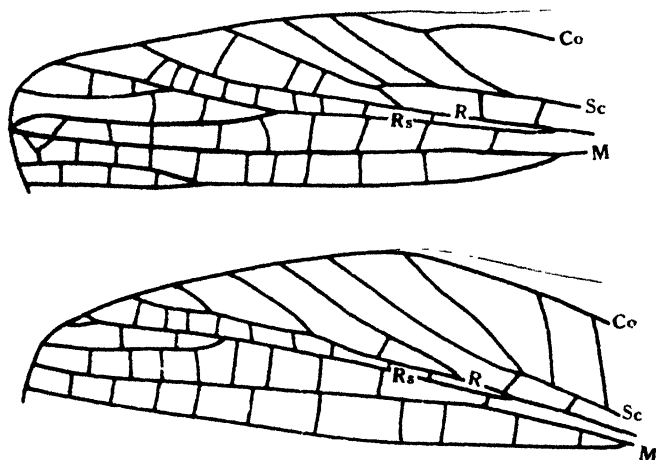


FIG. 3. *Gryllacris tuscineris exauda*. Apical half (anterior part) of left tegmen. Above: ♂ Paratype; below: ♀ Allotype.

Hind wings: Costal area without cross veins, or only one or two of them basad and distad. Subcostal vein simple. Radial vein emitting in distal part two oblique, distant fore branches into fore margin, like Phil. Journ. l. c. Plate 8, Fig. 3. $Rs + M$ also practically as in that figure, medial vein arising from it in the middle, radial sector then three-branched in about the apical third. Middle part of anal fan with 6 to 11 cross veins in each area.

Type and Paratypes in U. S. National Museum. Catalog No. 41226.

***Gryllacris ferruginea* Brunner, v. W.** (Plate I, Fig. 2).

1 ♂ (det. CAUDELL), Suva, Fiji, vi. 25, '22, DAYTON STONER, on *Guaya*. As it is the only *Gryllacris* species hitherto known from the Fiji Islands, I suppose that to the same species belongs

very probably also a very small larva (length of body 2.5 mm). from Mokaluva, Fiji Islands, June, STONER.

♂.—As to coloration, genitalia and venation quite typical, as described already in some others of my publications. Chief furcation of cubital vein on both tegmina of the specimen now before me arising at the end of basal fourth. Costal field of hind wings with cross veins throughout its whole length; radial vein with a short apical fork.

Gryllacris macilentia Pictet & Saussure

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 29, (*phryganoides*, nec DE HAAN).

1 ♂, Buitenzorg, Java, vi, '09, BRYANT & PALMER Coll. To the same species belongs very probably also 1 juv. ♂, (length of body, 9.5 mm), from the same locality and collectors, iv 10, '09.

The ♂ now before me is an unusually small specimen, viz.: Length of body 17.5, pron. 3.6, tegmen 15, fore fem. 5.8, hind fem. 10.8 mm. This suggests that SERVILLE's *pallidula* may be perhaps identical with this species, not with *auriculata* KRAUSS, as usually supposed. I shall return to this question in some other of my papers.

♂ genitalia and venation as usual in this species, but the latter somewhat reduced. Tegmina with two simple precostals. Subcostal vein emitting just after its middle one oblique anterior branch to costal vein. Both radial vein and radial sector with but a very short, simple, apical fork. Cubital vein simple on left tegmen, forked at beginning of the middle fifth on the right one, but the fore branch not reaching apical margin, ending just before beginning of the apical fifth of tegmina. Not more than four simple postcubital longitudinal veins. Hind wings cycloid. Costal area with but a few cross veins. Medial vein arising from Rs + M at the end of middle fifth. Anal fan in the middle with but 5 cross veins in each area, only in one or two areas with 6.

Gryllacris ruficeps Serville.

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 29.

1 ♂ (det. CAUDELL), Mt. Salak, Java, BRYANT & PALMER Coll. 1 ♀ (det. KARNY), Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD.

Both specimens in every respect quite typical (comp. Treubia, V, Pl. II, Fig. 6; Journ. F. M. S. Mus., XIII, p. 28, Fig. 12). Always six free, simple postcubital veins, but on left tegmen of ♀ the second of them (=An₁) forked at the end of basal third. Radial vein of hind wings with a short, apical fork, or emitting two oblique branches to the anterior margin.

Median vein arising from $R_s + M$ at about the middle of wing; Fig. 4 shows a portion of type tegmen of the male. Radial sector in both sexes four-branched. Middle part of anal fan with 7 to 10 cross veins in every area.

***Gryllacris lineolata* Serville.**

1 ♂ (det. KARNY), Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD.

Tegmina: Four simple precostals. Both last precostal and the subcostal vein on both tegmina arising from costal base. Costal vein forked beyond the middle. Subcostal vein with an apical fork, or emitting two oblique branches to the anterior margin. Radial sector forked, or with three branches. Cubital vein arising as usual in this species from radial stem, simple or bifurcate somewhat before the middle of tegmen. Five free, simple postcubitals. Radial sector of hind wings three-branched in apical fourth. Otherwise as described in Zeitschr. f. Naturw., lxxxviii, 1/2, p. 5; comp. moreover Treubia, V, p. 91, Fig. 30.

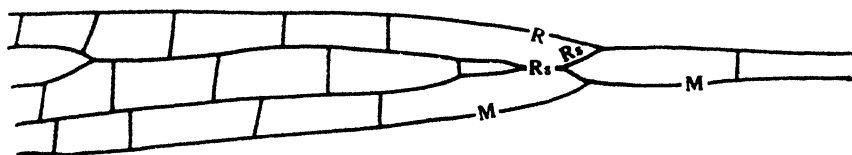


FIG. 4. *Gryllacris rufocephus*, ♂. Left hind wing, middle part of radial and medial vein.

***Gryllacris lineolata* var. *menzeli* Karny.**

1 ♀ (det. KARNY), Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD.

Gr. lineolata menzeli was originally described as a subspecies; but as the specimen now before me comes from the same locality as the typical form, it is to be regarded as a mere color variety.

Venation of tegmina as in the typical form.

***Gryllacris si-rambeica griffini* var. (Plate I, Fig. 7).**

1 ♀ (det. KARNY), Ft. de Kock, Sumatra, WIRT ROBINSON, Collector.

Measurements: ♀, length of body 25.5, pron. 7, tegmen 29.7, fore fem. 10.3, hind fem. 19, ovipos. 22 mm.

As I have shown in another paper, *si-rambeica* originally described as a subspecies of *aethiops* (GRIFFINI, 1908) is to be considered of specific rank, and *fuscifrons* var. *melanica*

GRIFFINI, 1909) does not belong to that species, but to *si-rambeica*.

The specimen now before me is about intermediate in its characters between the typical *si-rambeica* and its var. *melanica*. The coloration of head, pronotum and legs agrees fully with *si-rambeica*, whilst the hind wings are not "hyalino-tessellata" as in the typical form, but "fusco-fasciata" quite as in var. *melanica* (GRIFFINI, Boll. Mus. Zool. Anat. Torino, xxiv, 610, p. 8, Fig.). Venation of type IV, in every respect agreeing with that of *si-rambeica* and var. *melanica*, as described in another of my papers; the only difference is that the radial vein of hind wing in the specimen now before me is but simply forked in the apical part.

Gryllacris fuscifrons Gerstaecker.

1 ♂ (det. KARNY), Java, SAUSSURE.

I have shown in Treubia (X, 1, p. 73-88; 1928), that *variabilis* BRUNNER v. W. is nothing else than a synonym of *fuscifrons*. The specimen now before me has blackish fastigia, as typical for the true *fuscifrons* (s. str.). Venation of type IV, without any peculiarities or aberrations.

Gryllacris signifera (Stoll)

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 29.

1 ♀, Salak, Java. 2 ♂♂, 2 ♀♀, 1 juv. ♀, Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD. 1 ♀, Depok, Java, 8. 1. '09, BRYANT & PALMER Coll. 1 ♂, 1 juv. ♂, Buitenzorg, Java, iii, '09, BRYANT & PALMER Coll.

All specimens in every respect quite typical; venation of type IV, though somewhat variable, viz.: Costal vein of tegmina simple or with a few anterior branches, sometimes with an unusually long apical fork (Fig. 5, a). Radial sector emitting distad three to four branches backwards (Fig. 5 a), but in one case forward (Fig. 5, c); on the right tegmen of the Salak-♀ it emits one hind branch and then two fore branches (Fig. 5, b), thus being not regularly pectinate as otherwise always. One of the ♀♀ of FAIRCHILD collection represents on left hind wing a doubled origin of Rs + M (separately for medial vein and for radial sector)—a similar case as figured above for *ruficeps*; but the sector base meets here Rs + M before emitting medial vein, (Fig. 5, d). Compare with Fig. 4.

***Gryllacris personata* Serville**

1927 CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 29, (*falcata*).

As I have shown, *falcata* BRUNNER v. W. is a synonym of *personata* SERVILLE, whilst BRUNNER's *personata* is not the Servillean species, but a synonym of *eta* KARNY.

1 ♀ (*falcata* det. CAUDELL), Buitenzorg, Java, iii, '09, BRYANT & PALMER Coll.

A quite typical specimen. Coloration of face, see Treubia, VII, 1, Plate I, Fig. 7, d. Venation according type IV.

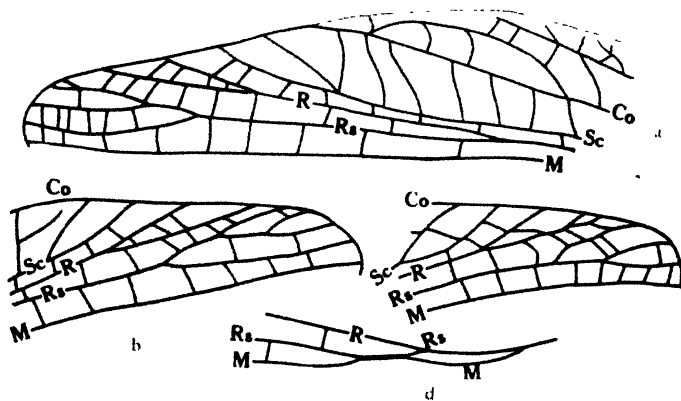


FIG. 5. Variations of tegminal and wing venation in *Gryllacris signifera*. (a) 1, Salak, preapical part of left tegmen; (b) the same, right tegmen; (c) first ♀, Fairchild collection, preapical part of right tegmen; (d) second ♀, Fairchild collection, doubled origin of Rs + M from radial vein on left hind wing.

***Gryllacris caudelli* n. sp. (Plate I, Fig. 8)**

1 ♀ (Holotype), Puerto Princesa, Palawan, P. I., Sept., 1925, R. C. MCGREGOR, Collector.

Measurements: ♀. Length of body 23.3, pron. 5.2, tegmen 23.5, fore fem. 8.3, hind fem. 13.7, ovipos. 18 mm.

1. A very peculiar species. Rather small and slender. General color cinnamon-buff with black.

Head a little wider than pronotum, obovate and somewhat elongate in frontal view; general color shining black, except occiput, vertex, fastigia, hind margin of genae, ventral and side margins of clypeus and the whole of palpi. Occiput strongly arched, clay-color, with a large, triangular, not well-defined dark brown spot in the middle. Supraocular sulci sharp. Vertex convex; fastigium verticis about as wide as first antennal segment, longitudinally shallowly excavate, with blunt, indistinct lateral carinae. Antennal scrobes shining black, only the weak pellicle at the insertion of first antennal joint paler,

greyish, though with a blackish spot inside. The five or six basal joints of antennæ quite shining black, the following ones gradually becoming paler, rest of antennæ yellowish brown. Frons shining black, about twice as wide as high, with a few strongly impressed dots, about as in *podocansta*, much fewer than in *modiglianii*, clypeo-frontal suture strongly impressed on either side and somewhat dilated mesad. Subocular sulci distinct, triangularly dilated downwards. Genæ smooth, black, narrowly clay-color along upper part of hind margin. Clypeus trapezoidal, in lower part with a sharp, deep length sulcus; color, shining black, narrowly bordered with cinnamon-buff below and outside. Mandibles and labrum shining black throughout, the latter about circular. Palpi long, cinnamon-buff; apical joint of labial palpi dilated distad, with a strongly oblique, excavate apical area.

Pronotum not very broad, including lateral lobes about as wide as long; sculpture practically as in *maculipes irregularis* (GRIFFINI, Ann. Mus. Nat. Hungar., IX, p. 175, 1911); hind angle of lateral lobes obliquely truncate. General color cinnamon-buff, with sharp, well-defined black markings, viz.: the median sulcus black in the middle third of the disc; on either side of its posterior end a short oblique black line; before its anterior end on either side a considerable, transverse black spot, and before this a fine oblique blackish line descending on lateral lobes towards but not quite to the fore margin. A very large black irregularly crescent-shaped spot about the middle of lateral lobes, the convex side dorsal. Behind this large spot is a small black dot just under the middle of hind oblique sulcus. Posterohumeral cone short and thick, but acute at apex. Prosternum unarmed. Meso- and metasternum impressed in apical part of median line; the former with obtusangulately excised hind margin and broadly rounded lobes; the latter rectangularly excised with bluntly rectangular lobes.

Tegmina much exceeding tips of posterior femora, pale yellowish, subhyaline, with longitudinal veins of the same color or a little darker; cross veins in about the apical half greyish and suffused on both sides by a greyish cloud. Four simple precostals, the last convex in basal part and then rather parallel to costal vein. This latter slightly S-curved, simple, ending about between the ends of middle fifth and third of tegmenal length. Costal area of the same constitution as the others, dilated distad, widest at the end of costal vein. Subcostal vein arising from costal base, straight, then curved forward before the end, emitting one or two short, oblique, anterior branches to the fore margin. Radial vein emitting in apical part two oblique anterior branches rather distant from each other to the anterior margin. Radial sector arising from radial vein about the middle of tegmen, with two posterior branches, the longer being hardly half as long as sectoral stem. Median vein arising from radial stem at about the beginning of the middle fifth, simple and free throughout. Cubital vein free from base, bifurcate just before the middle of tegmen. Now follows five simple longitudinal veins, the last two of them with a short common stem.

Hind wings cycloid, a very little paler than tegmina, with strong dark cross bands, even in the preanal part, the pale intervals between

them distinctly wider than the dark bands. Costal area with cross veins throughout the whole length. Subcostal vein unbranched, fused with radial basally. Radial vein forked before the end. $R_s + M$ arising from radial stem at the end of basal third, emitting the simple medial vein at the middle of wing. Radial sector emitting in apical third of wing two posterior branches which unite with each other in the distal part on left wing (Fig. 6), whilst remaining free to the apical margin on the right one. Cubital vein unbranched, arising from radial stem at about the end of basal sixth or seventh. Middle part of anal fan with 5 to 8 (usually 7) cross veins in each area.

Pleurae, coxae, trochanters and legs pale, cinnamon-buff, all femora in distal part well-defined shining black; fore tibiae black throughout, except the clay-color spines; middle and hind tibiae black in basal part and with a blackish spot before the end. All tarsi reddish-brown.

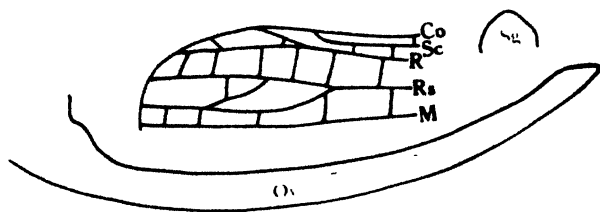


FIG. 6. *Gryllacris caudelli*, ♀ Holotype. Apical part of left hind wing; ♀ subgenital plate; ovipositor.

Fore coxae with a short, thick, sharply pointed spine. The movable spines of fore and middle tibiae of usual number, distinctly longer than the width of tibia. Hind femora in distal half with 6 to 7 dark-tipped spines on the outer ventral margin and 3 to 5 smaller ones on the inner margin. Hind tibia with 6 dark-tipped spines on each dorsal margin.

Abdomen pale, cinnamon-buff to clay, without dark markings; ♀ subgenital plate parabolic, not excised at the tip, considerably wider at base than long. Ovipositor one-third longer than posterior femora, equally and slightly upcurved, somewhat truncate apically and rather bluntly pointed, (Fig. 6).

Type in U. S. Nat. Museum. Catalog No. 41227.

I have the pleasure to name this brightly colored species in honor of Mr. A. N. Caudell, the well-known American Orthopterist, to whose kindness I owe the occasion of studying this interesting material.

This species was mistaken by CAUDELL for *vittipes* WALKER, because it is quite impossible to determine anything after the quite insufficient WALKER's descriptions. As I have studied all WALKER's type specimens of *Gryllacrids* (in the British Museum, London, and in the University Museum, Hope

Department, Oxford). I can state that *Gryllacris caudelli* is not near-related with that nor with any other Philippine species. Its nearest allies are amongst the Bornean species, viz.: *moultoni* GRIFFINI, *podocausta kuchingiana* GRIFFINI and *maculipes* WALKER. By the black head, it differs at once from *moultoni* and *maculipes* and agrees in this character and by the coloration of legs with *podocausta kuchingiana* only, but differing from it by coloration of pronotum, by the longer tegmina and wings, by the pale longitudinal veins of the former and the strong dark crossbands of the latter, moreover by much longer ovipositor. From *moultoni*, it differs by color of head, pronotum and legs and by the relatively longer ovipositor. From *maculipes* (and its var. *irregularis* GRIFFINI), *caudelli* differs by the black head, by different coloration of pronotum and by the color of tegminal veins which are paler than the areolæ between them in *maculipes*, whilst being of the same color and partly even darker in *caudelli*. The ♀ of *maculipes* is not yet known, as WALKER'S description is quite insufficient, and I could find in the material of British Museum only the ♂, not the ♀. But a ♀ from Borneo in the Leyden Museum collection, which agrees in many respects with *maculipes* though differing by some color characters, has a considerably shorter ovipositor than *caudelli* and the subgenital plate distinctly excised at apex.

Subfamily RHAPHIDOPHORINÆ

Rhaphidophora loricata (Burmeister), (nec. Kirby)

1838. BURMEISTER, Handb. Ent., II, p. 722, (*Phalangops*).

1839. SERVILLE, Hist. Nat. Ins. Orth., p. 391, (*puca*).

1906. KIRBY, Syn. Cat. Orth., II, p. 124, (*brunneri*).

1927. KARNY, Zeitschr. Nat., lxxxviii, p. 11.

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 28, (*deusta*, nec BRUNNER & W.).

1 ♂ (with a label "*deusta*," without indication of determinator), Buitenzorg, Java, iii, '09, BRYANT & PALMER Coll.
1 ♀, Mt. Salak, Java, BRYANT & PALMER Coll. 2 ♂♂, 2 ♀♀,
2 juv. ♂♀, Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD.

Quite typical specimens, also as to the shape of ovipositor, ♀ subgenital plate and ♂ styles; distinctly different from both *deusta* and *fulva*. (See my notes on these two species in the revision of Gryllacrids of Vienna Museum, now in press).

Family TETTIGONIIDAE.

Subfamily SCAPHURINÆ.

Comp. KARNY, Treubia, IX, p. 12-151; 1926

Elimaea (Rhaebelimaea) bakeri Hebard

1922. HEBARD, Proc. Ac. Nat. Sci. Philad., lxxiv, p. 125.

1 ♂, Malabang, Mindanao, MAJ. J. M. T. PORTILLO.
Rec'd July 31, '08.**Elimaea (Rhaebelimaea) filicauda** Hebard

1922. HEBARD, Proc. Ac. Nat. Sci. Philad., lxxiv, p. 127.

1 ♂, 1 ♀ (Allotype), Manila, P. I., August 21, 1924, R. C. Mc GREGOR, Collector

The ♀ of this curious species, is as yet unknown. It agrees quite all right in every respect with the ♂. Its measurements are:

♂, Length of body 25, pron. 13, tegmen 39, width of tegmen 5.5, length of fore fem. 9, hind fem. 35.3, ovipos. 5.7 mm.

Ovipositor short, strongly compressed, upcurved, blunt at apex, upper margin and end of lower margin denticulated; ♀ subgenital plate triangular, rounded at apex, a little wider at base than long, without any processes.

Elimaea (Rhaebelimaea) kraussi Karny1903. KRAUSS, SEMON, Zool. Forsch. Austral., V, p. 748, 762, (*signata*, nec BRUNNER, v. W.)1923. KARNY, Journ. Mal. Br., R. As. Soc., I, p. 135, (*parumpunctata*, nec SERVILLE).

1926. KARNY, Treubia, IX, 1-3, p. 31, fig. 92

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 33, (*curvicerata*, nec BRUNNER v. W.)

1 ♂, Mt. Salak, Java, BRYANT & PALMER Coll.

I have not yet seen BRUNNER's *curvicerata*; but it is recorded from Eastern Java only and seems from BRUNNER's description to differ from *kraussi* by the sexual characters. Thus, I cannot believe that they are identical.

Elimaea (Elimaea) poaeifolia (De Haan)

1926. KARNY, Treubia, IX, 1-3, p. 37, fig. 97.

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 33, ("species").

1 ♀, Pelaboean Ratoe, Java, BRYANT & PALMER Coll.

CAUDELL (l. c.) stated quite correctly that it "is apparently allied to the *E. rosea*," but he seems to have overlooked that the Western Javanese species of the *rosea* group is *poaeifolia* DE HAAN, 1842.

Aphroptera biroi Bolivar

1 ♂, New Guinea, B. P. CLARK, donor.

Agreeing with BOLIVAR's description, except that the antennæ are uniformly ferrugineous, without black basal joints nor with distinct pale rings. The black stripe on fore tibia very distinct.

Paracaedicia verrucosa Brunner, v. W

1 ♂, New Guinea, B. P. CLARK, donor

I have completed BRUNNER's description in 1926 in *Treubia* (IX, p. 65).

Ancylecha fenestrata (Fabricius).

1 juv. ♀, Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD.

This stage described and figured in *Treubia*, 1921 (I, 4, p. 296).

Casigneta spec

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 33, ("*Symmachis subroseata* Walker?").

1 ♀, Buitenzorg, iii, '09, Java, BRYANT & PALMER Coll.

Measurements: Length of body about 14, pron. 3'5, tegmen 27'7, fore fem. 4'8, hind fem. 18'8, ovipos. 5'6 mm.

I cannot believe that the genus *Symmachis*, without exception Australian, should occur in Western Java. The specimen before me agrees very well with the *cochleata* group of *Casigneta* by shape of fastigia, venation of tegmina, shape of ovipositor and of ♀ subgenital plate. But the tympana of fore tibiæ are distinctly open on both sides, whilst being conchate inside in *Casigneta*. The specimen before me has only one fore leg and the tarsal joints of it are very short and weak, though normal in number; thus, it may be probably an anomalous fore leg (regenerate?), and in such we find very often open tympana instead of normally conchate ones. I find it best, therefore, to place this specimen to *Casigneta*, which is represented in Java too, but I do not know hitherto any Javanese species of the *cochleata* group. This specimen is, therefore, very probably to be considered as a new species, though it is impossible to describe it from a ♀ only.

***Elbenia nigrosignata* Stal**

2 ♂♂, Puerto Princesa, Palawan, P. I., October, 1925, R. C. MCGREGOR Coll.

They may perhaps represent a distinctive local race or subspecies of this species described from Malay Peninsula, though the material before me is too poor to decide this with certainty. The only difference I can state is that the narrow, sharply pointed lobes of anal segment are rather parallel (Fig. 7), much less divergent than in typical *nigrosignata*.

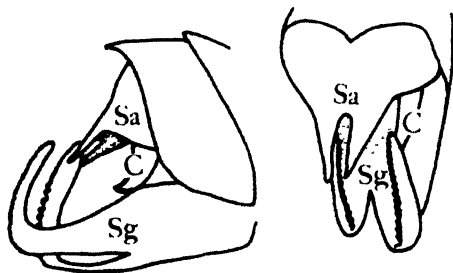


FIG. 7. *Elbenia nigrosignata* from Puerto Princesa, Palawan
End of ♂ abdomen in lateral and hind view.

***Psyra melanonota* Stal**

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 34. (*borneensis*, nec BRUNNER v. W.).

1 ♂, Buitenzorg, Java, iii, '09, BRYANT & PALMER Coll.

Though CAUDELL has determined it for *borneensis*, he compared it with *melanonota* too (l. c.), stating that in the cerci "the subapical inner tooth is smaller than in a male of that species determined by Hebard from the Moluccas." But this is a variable character in this species as stated by HEBARD in 1922, (Proc. Ac. Nat. Sci. Philad., lxxiv, p. 154). Though the western specimens of *melanonota* usually have the whole disc of pronotum reddish brown, the specimen before me shows this color in the posterior portion only, margined behind by black. Otherwise no difference from typical specimens; also the bright bicolorous costal stripe in tegminal base is present.

***Holochlora paradoxa* Karny.**

1926. KARNY, Treubia, ix, 1-3, p. 122.

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 34. (*venosa*, an STAL?)

1 ♀, Buitenzorg, Java, iii, '09, BRYANT & PALMER Coll.

As I have discussed l. c., it is not quite impossible that my *paradoxa* may prove to be a synonym of *venosa*, but STAL's description is too laconic to make it out with certainty.

***Holochlora signata bogoriensis* Karny.**

1926. KARNY, Treubia, IX, 1-3, p. 124.

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 34, (*Psyra unicolor*, nec BRUNNER, v. W.).

1 ♂, Mt. Salak, Java, BRYANT & PALMER Coll.

CAUDELL has mistaken it for a *Psyra*, as he had no ♀ specimen before him, and the generic differences between *Holochlora* and *Psyra* are based, unfortunately, on ♀ characters only. As I know also the ♀ ♂ of *bogoriensis*, there can be no doubt that its position in *Holochlora* is correct.

Subfamily PTEROPHYLLINÆ.

***Pseudophyllus titan* White**1895. BRUNNER, v. W., Mon. Pseudophyll., p. 10, (*Cleandrus rev.*).

1 ♀ (det. CAUDELL), Lem Sing Prov. of Chantabun, S. E. Siam, June 12, 1926, H. M. SMITH Coll.

***Onomarchus* spec**1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 32, (*Pseudophyllus titan*, nec WHITE).

1 juv. ♂, 1 juv. ♀, Buitenzorg, Java, iii, '09, BRYANT & PALMER Coll.

The spines of hind legs are much better developed in young specimens than in adults, and resemble very much *Pseudophyllus titan* indeed. This is the reason that CAUDELL mistook them for that species. But the shape of pronotum, on the other hand, is quite typical for *Onomarchus*. I kept repeatedly such juveniles living, and they develop to quite typical *Onomarchus* adults. They belong, thus, certainly to one of the two following species, but I am not able to distinguish them in this stage.

***Onomarchus leuconotus* (Serville).**1839. SERVILLE, Hist. Nat. Ins. Orth., p. 469, (*Pseudophyllus*).1892. PICTET & SAUSSURE, Icon. Saut. Vertes, p. 15, (*latipennis*).

1924. KARNY, Treubia, V, 1-3, p. 179.

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 32, (*leuconotus* partim).

1 ♂ ("*leuconotus* var. *latipennis*" det. CAUDELL), Depok, Java, I. viii, '09, BRYANT & PALMER Coll. 1 ♀, Buitenzorg, Java, iii, '09, BRYANT & PALMER Coll.

***Onomarchus mandarinus* Pictet & Saussure.**

1 ♂, Java, Nr. 296. 1 ♀ ("*leuconotus*" det. CAUDELL), Mt. Salak, Java, 15. v. '09, BRYANT & PALMER Coll.

BRUNNER, v. W. in his monograph (p. 43) has confounded this species with the preceding one, and CAUDELL followed him in this (l. c.). Other authors have named the species "*cretaceus*," but the Servillean description makes it clear that this must be regarded as identical with *submuticus* BRUNNER, v. W., as I have shown in 1924 (Treubia, V, 1-3, p. 178, 180). Thus, the only available name for it is *mandarinus*.

***Despoina submutica* n. sp.** (Fig. 8).

1 ♂ (Holotype), Mt. Kinabalu, N. Borneo, 5-6,000 ft., A. D. DODGE & G. A. GOSS, collectors.

♂, Length of body 34, pron. 6, tegmen 62.5, fore fem. 7.8, hind fem. 17 mm.

A very distinctive species, running by its much produced, lobate conchs of fore tibial auditory organs to *Despoina* BRUNNER, v. W.

General color yellowish green, head and pronotum more yellow. Antennae unicolorous, yellowish, without any dark markings. Pro-

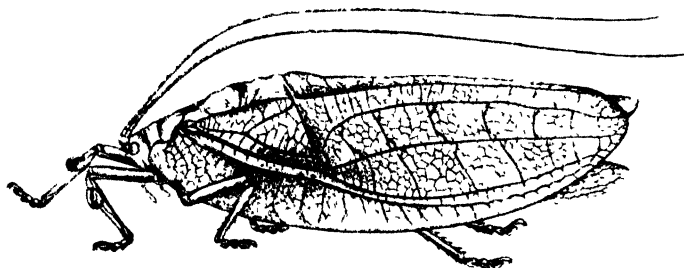


FIG. 8. *Despoina submutica*, ♂ Holotype. Natural size
(SOEHANAM del.)

notum with fore and hind margins equally rounded, smooth. Disc with one indistinct and close behind it one very sharp, deep cross sulcus, this latter situated before the middle; no longitudinal sulcus, except a very short longitudinal groove crossing the second transverse sulcus; surface of pronotum sprinkled irregularly with blunt, very short teeth, not situated in rows, reaching neither fore nor hind margin. Color uniformly pale, except the second cross sulcus, which is brownish red, and a narrow curved line just along hind margin of the same color which is triangularly dilated in the middle. The hind margin itself pale.

Tegmina very long and wide; pale green; the strong cross vein of stridulating field (left tegmen) broadly bordered with ferrugineous brown, and some of the irregular cross venules of anal area of the same color. The long, regular cross veins of the distal two-thirds between radial vein and radial sector, and between radial sector and medial vein, rose colored with an intensively yellow spot at junction with

longitudinal veins. Subcostal and radial veins distant from each other throughout their whole length, about as in *spinosa*. Radial sector arising from radial vein at about the end of basal third. Medial vein equally distant from radial in basal third as the radial is from the subcostal vein, then strongly curved backwards; radial sector equally distant from radial as from medial vein. Stridulating field much shorter than in *superba*.

Legs pale brownish yellow. Fore and middle femora beneath on both margins with some small spines, those of the former bearing very minute, serriform denticles, those on the latter somewhat larger. Posterior femora with about a dozen stronger spines increasing apically on either lower margin. Conchs of fore tibial tympana strongly lobate, arched, rounded. ♂ genitalia as usual in this and the allied genera.

Type in U. S. National Museum. Catalog No. 41228.

Sathrophyllia femorata (Fabricius)

1924. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 33.

1 ♀, Buitenzorg, Java, April-December, '96, D. G. FAIRCHILD.

Subfamily MECONEMINÆ.

As I have shown in 1924 (Treubia, V, 1-3, p. 105-108), the genus *Xiphidiopsis* does not belong to the Listroscelinæ, where it was previously placed by the authors, but certainly to the Meconeminæ.

Xiphidiopsis picta Karny.

1924. KARNY, Treubia, V, 1-3, p. 110, 113, fig. 37.

1927. CAUDELL, Proc. U. S. Nat. Mus., lxxi, 3, p. 30, (*fallax*, nec REDTENBACHER).

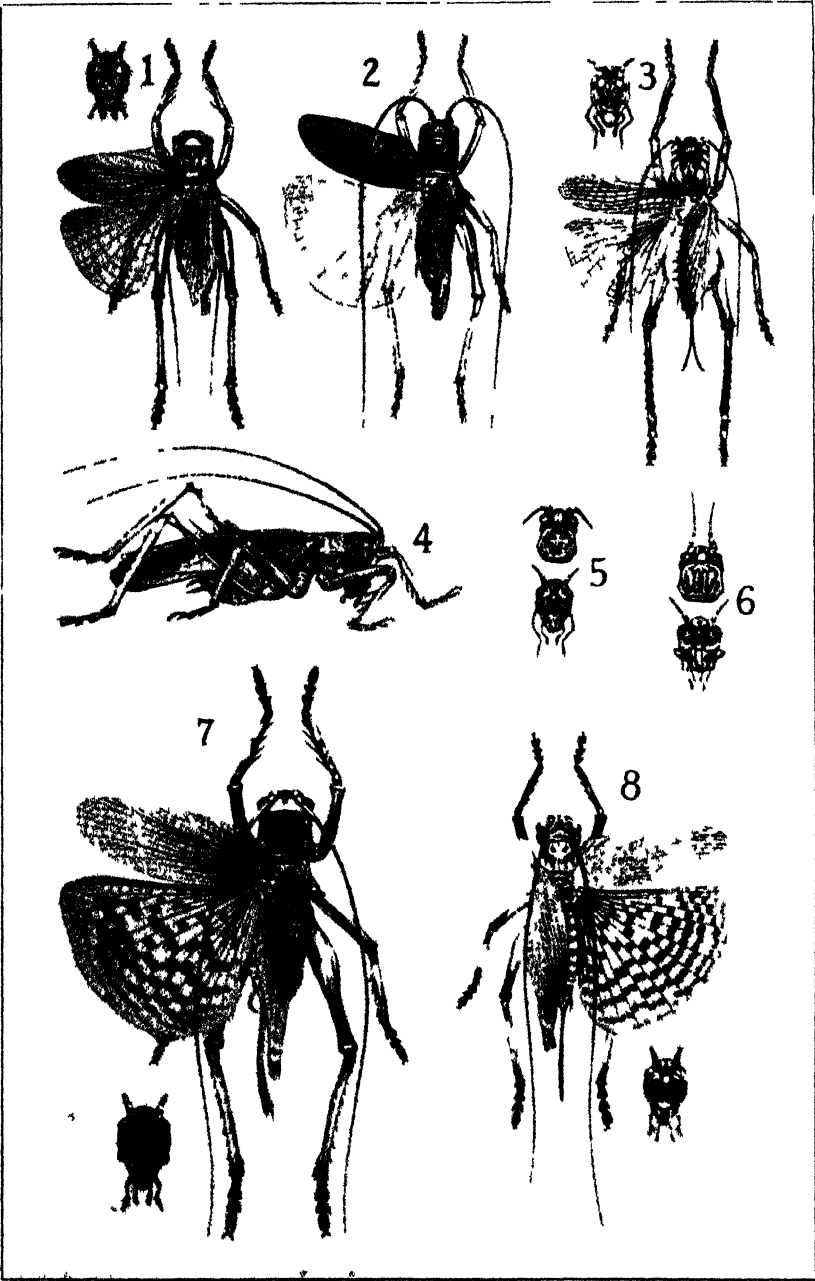
1 ♂, Mt. Salak, Java, 15. v. '09, BRYANT & PALMER coll.

Compared with type specimens in Buitenzorg Museum and agreeing with them in every respect. Differing from *fallax* by coloration and by the shape of ♂ genitalia, though REDTENBACHER's description is not sufficient. *X. fallax* is an Eastern Javanese species and does not occur in Western Java.

EXPLANATION OF PLATE.

(Slightly less than natural size, SOEHANAM del.)

- Fig. 1. *Gryllacris fuscinervis evanida*, ♂ holotype.
- Fig. 2. *Gryllacris ferruginea*, ♂.
- Fig. 3. *Gryllacris fuscinervis evanida*, ♀ allotype.
- Fig. 4. *Gryllacris melanocrania*, ♂ holotype.
- Fig. 5. *Gryllacris fuscinervis evanida*, ♂ paratype.
- Fig. 6. *Gryllacris fuscinervis evanida*, ♀ paratype.
- Fig. 7. *Gryllacris si-rambeica* var., ♀.
- Fig. 8. *Gryllacris caudelli*, ♀ holotype.



BASES FOR THE GENERIC CLASSIFICATION OF THE COCCOID FAMILY COCCIDÆ.

JOHN BENJAMIN STEINWEDEN,
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INTRODUCTION.

The group of scale insects here to be considered has commonly been characterized as the Lecaniine scales, owing to the fact that the genus *Lecanium* was for long regarded as its type. With the shifting of the group type to the genus *Coccus* it has been generally accepted as the subfamily *Coccinae* of the family *Coccidae*. The group appears, however, to be of family rank, a position that has been suggested by Professor Ferris, and it will therefore be treated in this paper as the family *Coccidae* of the superfamily *Coccoidea*¹.

The group is generally considered to be very difficult and previous systematic work has contributed comparatively little to the understanding of the relationships and the classification of the existing forms. But little attention has been paid to the more obscure morphological characters and most of the keys are based upon external appearances, body secretions and comparative measurements of legs and antennæ, all of which have proved to be inadequate and in many cases quite useless. In this study I have attempted to establish a classification based primarily upon morphological characters.

Sixty or more genera have been named in this group and of these I have examined representatives of thirty-two, these including especially the older genera. Habit, body secretions, the males and comparative measurements are but briefly considered. The work has been based almost entirely upon the morphological characters of the adult females and of the first stage larvæ, where the latter were obtainable. While eventually the males must be studied also, that has not been possible as yet, owing to the scarcity of material.

¹Although the spelling *Coccidoidea* has previously been used for the superfamily name of the scale insects, it would appear that the proper form is *Coccoidea*.

Acknowledgments are due to Professor G. F. Ferris, by whom this paper was suggested and who has given advice and other aid in its preparation. They are also due to Mr. E. E. Green for the gift of valuable material and for helpful suggestions that he has offered. The material upon which the paper is based has for the most part come from the collection of *Coccidae* of Stanford University.

METHODS.

Much of the difficulty experienced in dealing with this group has been due to the unsatisfactory methods usually employed in the preparation of microscopic mounts. First class preparations are essential for systematic work and I have used specimens that were cleared, stained and mounted according to the methods of modern Coccidologists.

In preparing material it is important to secure specimens that are in the early adult stage when the derm is soft and membranous. If the derm has become sclerotic and pigmented it is impossible to determine the character of the ducts and pores, which are very important in a systematic study of the group.

POSITION OF THE GROUP.

As I have previously stated, I am here treating the group as a family of the *Coccoidea*. It may be defined by the following characters. *Coccoidea* in which the adult female possesses an anal cleft the base of which is covered by an operculum formed of two plates; anal opening invaginated and surrounded by a distinct, setigerous anal ring; usually with four stigmatic depressions with prominent stigmatic setæ; usually with well developed legs and antennæ. Without abdominal spiracles, dorsal ostioles, cerarii, or brachii.

There are two theories as to the possible relationships of this family with the other families of the *Coccoidea*. One, held by Mr. E. E. Green, maintains that they are most closely related to the forms that group about *Eriococcus*. The other suggests a relationship to the forms centering about *Asterolecanium*.

The theory of relationship to the Eriococcids is based principally upon the similarity of the anal plates of the *Coccidae*

to the anal lobes in the former group. *Mallococcus*, a Coccid, has small, lobe-like anal plates much like the anal lobes of some Eriococcids. *Pseudo-pulvinaria sikkimensis* Atk., too, has small anal plates around the anal ring which look like the anal lobes of Eriococcids. In fact this species has been placed with the Eriococcids. It is not difficult to imagine the anal lobes becoming retracted into an anal emargination and finally forming plates at the anterior end of a cleft. The first stage larval forms of *Eriococcus* have sclerotic anal lobes that are very similar to the anal plates of first stage Coccids. The fact that the anal plates of this stage in the Coccids bear a long apical seta, as do the anal lobes of the *Eriococcids* and many other forms, would seem to indicate this homology.

On the other hand, in support of the theory of relationship to the Asterolecaniids, there is the fact that certain of the *Coccidæ* possess S-shaped pores that resemble those of the Asterolecaniids, although they are apparently not identical in structure. The adult females of *Lecaniodiaspis* have slight stigmatic depressions, which bear modified stigmatic setæ. They have also a shallow anal cleft, the base of which is sclerotic. It has been suggested that anal plates could have been evolved from these sclerotic areas. The first stage larvæ of *Lecaniodiaspis*, however, have no structures resembling the anal plates of the first stage *Coccidæ*.

It appears probable, therefore, that the closest relationship of the group is actually with the Eriococcids. Professor Ferris who has previously held a belief in a connection with the Asterolecaniids now accepts the opposing view.

The genus *Aclerda* has been placed with the *Coccidæ* by some authors. Green has questioned this position and has placed the genus alone in an isolated position. Teague, who has reviewed the genus *Aclerda*, concurs in this opinion and excludes the genus from the *Coccidæ*. With this opinion I concur.

THE EXISTING GENERIC CLASSIFICATION.

The existing generic classification of the *Coccidæ* is based almost entirely upon external characters such as the presence or absence of an ovisac; the presence or absence of a waxy body covering and its character; the shape of the body, whether oval or elongate, convex or flat; the habits of the insects,

whether arboreal or subterranean the character of the derm, and color. Such characters are easy to recognize, but are too indefinite to make accurate discrimination possible or to serve

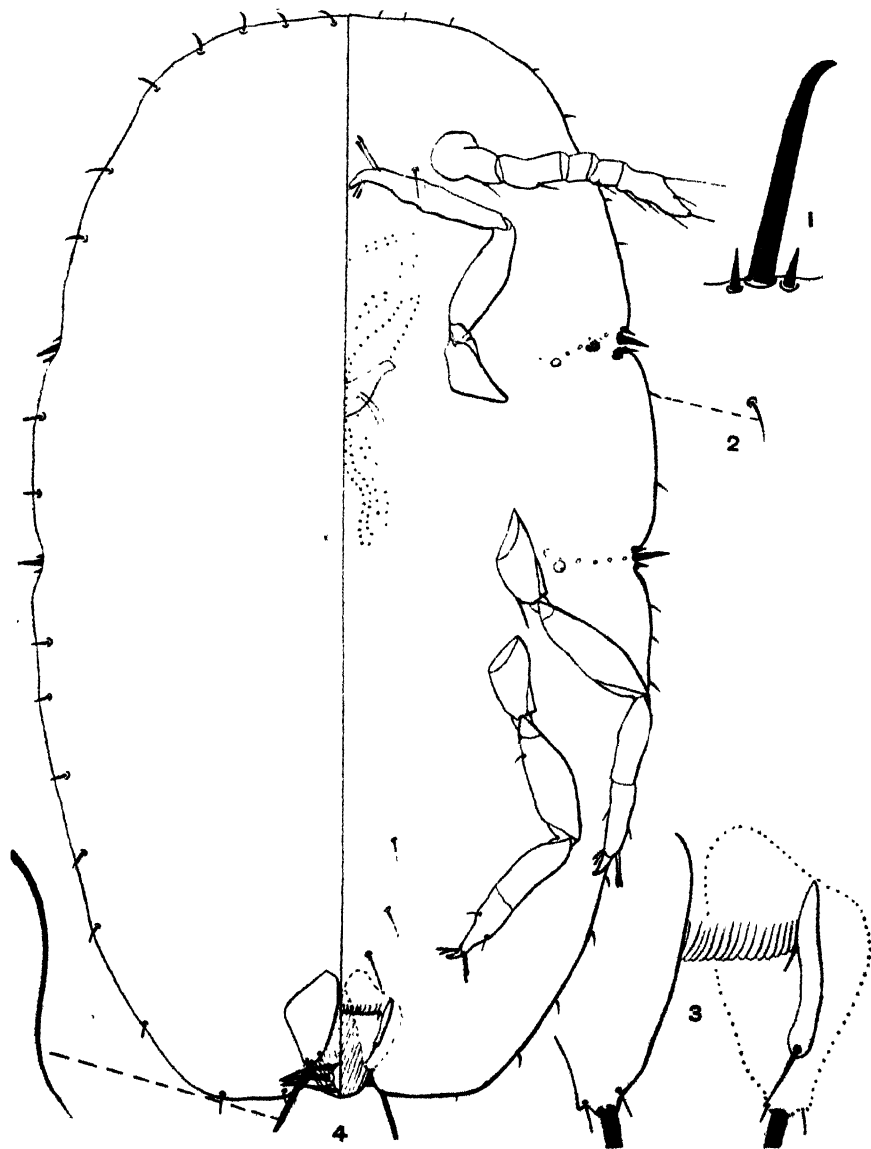


Fig. 1. *Coccus hesperidum* Linnaeus, first stage. 1, stigmatic setae; 2, marginal seta; 3, anal plates; 4, general outline.

as the fundamental bases of a classification. Commonly but little attempt has been made to utilize morphological characteristics of a more obscure nature, either because such characters are not easily observed or because they have not been thought necessary in taxonomic work.

As a result we have generic keys for this group which are of little practical value for classification, and a group of genera indefinitely defined and probably including many misplaced species. In the following pages several changes are made in the generic classification, all of these being based upon morphological studies

MORPHOLOGY OF THE FAMILY.

LEGS.

All of the members of the family retain the legs in the adult female, those of the majority of the species being well developed with all parts present. A few have the legs somewhat reduced, while in two genera examined, *Cryptostigma* and *Cardiococcus*, they remain merely as unsegmented vestiges. The legs most typical of the group are large, with all the parts present, with two slender digitules arising from the dorsal aspect of the tarsus and two stouter digitules from the claw. In *Coccus*, *Saissetia*, *Pulvinaria*, *Lecanium*, *Ceroplastes* (with the exception of *C. rubens*), *Lichtensia*, *Vinsonia*, *Inglisia*, *Malloccoccus* and several other genera the legs are well developed.

In *Physokermes*, *Eriopeltis*, *Lecanopsis* and *Ceroplastes rubens* the legs are somewhat reduced, but all the parts are present. In *Toumeyella*, and *Neolecanium*, the reduction in size has been carried still farther but still all the parts are present. In *Cryptostigma* and *Cardiococcus fossilis* only the claw can be recognized.

Although many descriptions pay much attention to the legs, giving the measurements of the parts in microns and describing minutely the vestiture of setæ, I have found such characters to be of but little taxonomic value. Where the legs are reduced this character may be of supplementary value, but it cannot serve as a primary basis for classification. *Ceroplastes rubens*, although in all other respects typical of its genus, has the legs greatly reduced. In the case of *Cryptostigma* and *Cardiococcus* the character is undoubtedly important.

One character of the legs that is important is that of the presence or absence of a free tibio-tarsal articulation. Green² has called attention to this character and states that typical examples of the genus *Pulvinaria* have a free tibio-tarsal articulation with a heavily sclerotic articular process interlocking with the distal extremity of the tibia. I have found this condition to hold in all the species of *Pulvinaria* that I have seen and in *Saissetia hemisphaerica* (Fig. III, 4). I have also found the typical species of *Lecanium* to lack this free articulation, a character for the separation of these closely related genera thus being available. *Coccus hesperidum* also lacks this free articulation (Fig. II, 4). In the generic diagnoses following attention is called to this.

All of the *Coccidæ* that I have examined have the tarsi one-segmented. *Exaeretopus* was originally described by Newstead as having the anterior tarsi dimerous, but Green has shown that this interpretation is erroneous, there being no true articulation. The apparent joint is merely a wrinkle formed because of the curvature of the tarsus. I have found an apparently rudimentary suture in *Eucalymnatus tessellatus*, *Hemilecanium imbricans* and *Takahashia japonica*.

ANTENNÆ.

The antennæ, like the legs, have been used often in generic and specific descriptions, their total length and the number and lengths of the individual segments having been relied upon. In this paper I am concerned principally with generic characters and have found the antennæ to be of but little value. In most of the Coccid genera the antennæ are long, fairly slender, six- to eight-segmented, the third and fourth segments usually being the longest. The basal segment is stouter than the others, which usually taper to a slender, pointed apex. *Coccus*, *Saissetia*, *Pulvinaria*, *Lecanium*, *Ceroplastes* (with the exception of *rubens*), *Lichtensia*, *Vinsonia*, *Malloccoccus* and several other genera have antennæ of this type. In *Takahashia*, *Physokermes*, *Inglisia*, *Cryptes*, *Eriopeltis* and *Ceroplastes rubens* the antennæ are of this same general type but shorter. In *Toumeyella*, *Neolecanium*, *Pseudophillipia*, *Lecanopsis*, *Cryptostigma*

²Green, E. E. Observations on British Coccidæ II. Ent. Mon. Mag. 64: 22; f. 2, (1928).

and *Cardiococcus* the antennæ are quite small, being reduced to four or five segments.

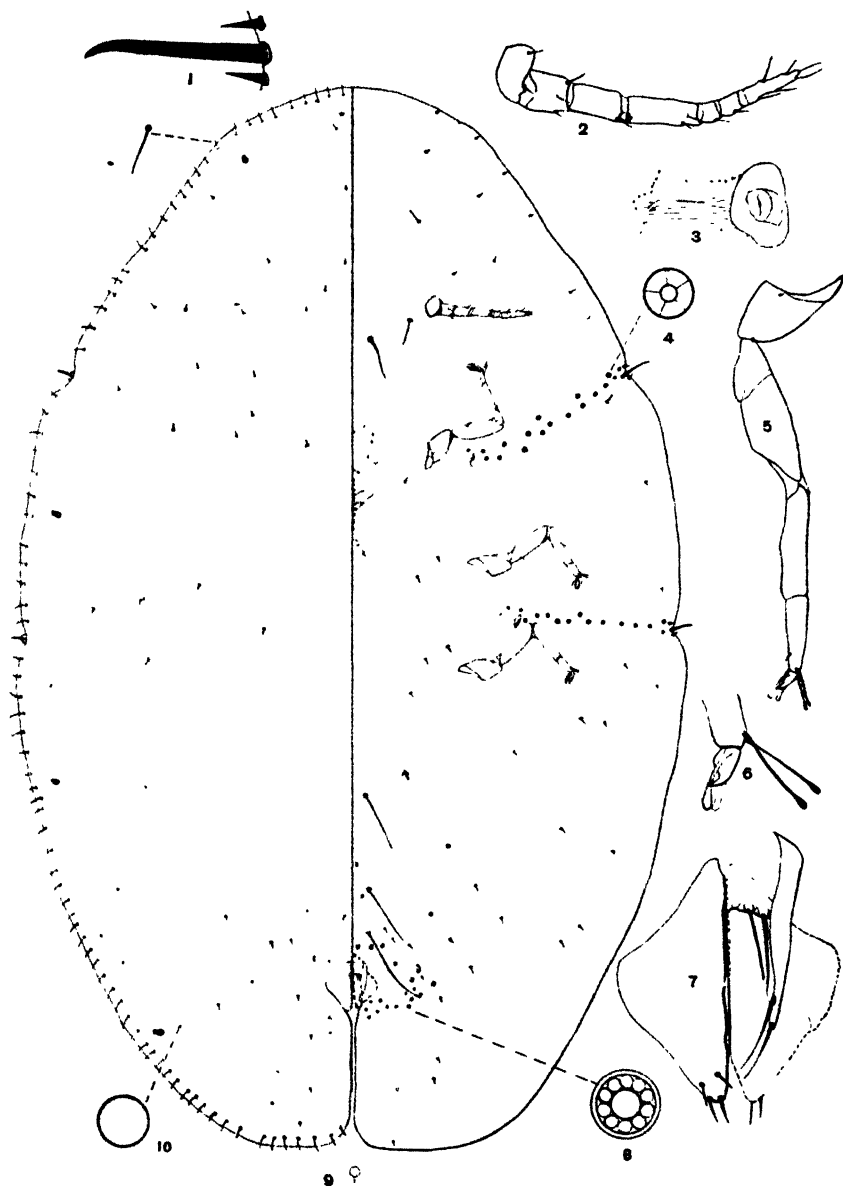


Fig. 11. *Coccus hesperidum* Linnaeus, adult female. 1, stigmatic setæ; 2, antenna; 3, spiracle; 4, quinquelocular pore; 5, leg; 6, claw; 7, anal plates; 8, multi-locular pore; 9, general outline; 10, simple pore.

There is a certain correlation between the character of the antennæ and the legs, those species with large, well developed legs usually having well developed antennæ and a reduction in the antennæ usually accompanying a reduction in the legs.

ANAL PLATES.

The posterior cleft and the anal plates appear as the most characteristic features of this group and consequently have received considerable attention from students. The two heavily sclerotic plates, forming the anal operculum are usually triangular in shape and lie at the base of the anal cleft above the opening of the anal tube. They are supported usually by two sclerotic, internal processes. These plates are present in the larval stages of all species and in the adults excepting only the genus *Physokermes* in which they are lost at the second molt, giving way to a membranous median lobe.

Setæ may be borne on various parts of the plates, as *apical setæ* at or near the apices, *discal setæ* on the dorsal surface, *subapical setæ* on the ventral surface, *fringe setæ* along the margin of the fold made by the invagination of the anal tube and *hypopygial setæ* on the ventral surface of the body just anterior to this fold.

The anal opening is borne at the inner extremity of a short, membranous, eversible tube and is surrounded by a well defined ring which bears six or eight stout setæ. The comparative length of the anal cleft, the number and arrangement of the setæ, and the shape and comparative proportions of the plates have all been utilized in systematic work.

In searching for structural characters of use in taxonomy I have studied the anal plates of many species in the more important genera and have found that in generic diagnosis the anal plates of themselves are generally of little value. They are useful for specific differentiation and in a few cases for generic classification. Examples of genera that may be defined by means of the anal plates follow.

Cissococcus: Plates elongate, lateral margins rounded and not angulate, disc closely beset with short, stout setæ.

Protopulvinaria: Anal cleft running far into the body, cephalolateral margin of the plates much longer than the caudolateral margin, the plates themselves much longer than wide.

In some genera the plates present supplementary characters for generic diagnosis.

Saissetia: A single large discal seta present on each plate.

Ceroplastes: Plates borne on a tubercle.

Toumeyella: Hypopygial setæ present, small discal setæ present on the posterior half of the plates, operculum quadrate.

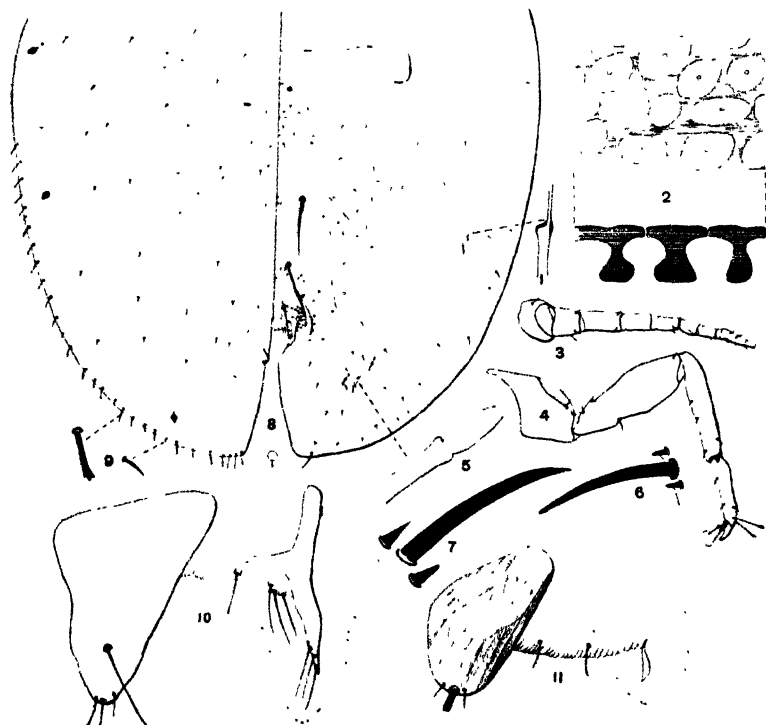


Fig. III. *Saissetia hemisphaerica* (Targ.). 1, small tubular duct; 2, portion of derm of adult female; 3, antenna; 4, leg; 5, large tubular duct; 6, stigmatic setæ of first stage; 7, stigmatic setæ of adult; 8, posterior portion of body of adult; 9, marginal setæ; 10, anal plates of adult; 11, anal plates of first stage.

In the larger, less well-defined genera, such as *Coccus*, *Lecanium* and *Pulvinaria*, where diagnostic characters are especially needed, the anal plates offer little aid.

ANAL RING.

The anal ring of the adult female generally has six or eight large setæ and is perforated by pores. The setæ may all be the

same size or one pair may be smaller than the others, but they vary in size and number within a single genus, so that the anal ring appears to be of use only as a specific character.

The very obscure vulva lies on the ventral side of the body anterior to the anal cleft, in most species it is very difficult to discern.

SPIRACLES AND STIGMATIC DEPRESSIONS.

There are two pairs of thoracic spiracles, the first pair just posterior to the first pair of coxæ and the second pair posterior to the second pair of coxæ. In structure they present a strong, sclerotic plate which bears the spiracular opening. In general they are some distance from the margin (Fig. II, 3, 9), but in a few species this is not the case.

At the body margin, opposite each spiracle, there is usually a depression, the stigmatic depression, which may be very faintly indicated as in *Coccus* and *Saissetia*, very well marked as in *Ceroplastes*, or obsolete as in *Toumeyella*. Stigmatic setæ of variable form and number but usually quite distinct from the marginal setæ occur in these depressions. Leading from the stigmatic depression to the corresponding spiracle there is usually a well-defined furrow which is marked by quinquelocular pores.

The spiracles themselves appear too generalized in form to be of much taxonomic importance, but the stigmatic depressions, the stigmatic setæ and the number and arrangement of the pores in the stigmatic furrow are useful.

MARGINAL SETÆ.

The members of this family usually have about the margin of the body a fringe of setæ of varying form, size and distribution. Some types of marginal setæ are useful in classification. In *Paralecanium* the setæ are flabellate. In *Hemilecanium* the fringe consists of many large, hastate setæ crowded closely together. In *Inglisia* the setæ are of two kinds, some slender and tapering, others stout and clavate. Other genera with distinctive marginal setæ are *Ceroplastodes* and *Filippia*. In *Pseudophilippia* and *Physokermes* the marginal setæ are lacking in the adult.

In many genera the setæ are of a more or less common type, offering characters of but specific importance. The primary

genera, *Coccus*, *Lecanium* and *Pulvinaria*, cannot be separated on the basis of these setæ, there being no correlation between the setæ and any other characters that seem to define the genera.

STIGMATIC SETÆ.

The modified setæ of the stigmatic depressions vary considerably in form and number. There are typically three setæ in each depression, these usually distinctly larger than the marginal setæ and differing from the latter in form. Commonly the three stigmatic setæ are subequal in length, or with the



Fig. IV. *Pulvinaria vitis* (Linnaeus). 1, posterior portion of body of adult female; 2, tubular duct; 3, anal plates of adult; 4, stigmatic setæ of adult; 5, leg of adult; 6, antenna of adult; 7, stigmatic setæ of first stage; 8, anal plates of first stage.

central seta longer than the others. Some forms have but two such setæ in each depression, these usually equal in length, or there may be but a single seta. *Ceronema* is distinctive by having six setæ, these rather small, blunt and subequal in length. In *Physokermes* and *Pseudophilippia* the stigmatic setæ are wanting in the adult at least.

In some genera these setæ are not distinguishable in form or size from those of the marginal series, such a condition being found in *Toumeyella*, *Pseudopulvinaria*, *Hemilecanium*, *Inglisia*, *Eriopeltis*, *Takahashia japonica*, *Philephedra*, *Exaeretopus*, *Lecanopsis* and *Cryptostigma*.

As taxonomic characters the stigmatic setæ are only auxiliary and I have found them of no value for generic separation of *Coccus*, *Saissetia*, *Lecanium* and *Pulvinaria*. In *Ceroplastes* they are quite distinctive, and in some other forms they are of some aid.

BODY SETÆ.

The typical vestiture of the members of this family consists of a few small, pointed dorsal and ventral setæ, scattered over the body, with two or three about the base of each antenna and usually with three pairs of larger setæ in the perivulvar region. The number and size of the setæ between the antennæ and the number, shape, size and distribution of those on the abdomen all afford good specific characters. For generic characters the body setæ are too general in form, number and arrangement to be of aid except in a few cases. In *Mullococcus* the setæ on the dorsum are quite large, conical and are set in pits. In *Eriopeltis* they are very numerous, large and in the form of a truncate cone.

LARVÆ.

The first stage larvæ (Fig. I) are always active, have well-developed legs and antennæ—the latter usually being six-segmented—have an anal cleft and have the anal plates more or less in the form of lobes and each bearing a long seta at the apex. In all the forms examined the antennæ are six-segmented except in *Toumeyella*, *Pseudophilippia* and *Takahashia jaliscensis*, where they are five-segmented.

Except in a few genera, the larvæ differ from the adult females in the stouter legs, the reduced antennal segmentation, the general reduction of the number of pores and body setæ, and by the possession of long apical setæ on the anal plates. Exceptions to the general condition appear in the first stage of *Mullococcus*, *Pseudophilippia* and *Ceronema*, which have 8-shaped pores, and *Cryptes* with a double row of large dorsal setæ.

The first stage of the male can not be distinguished from that of the female. The sexes may first be differentiated when the male puparium is formed.

The general similarity of form of the first stage larvæ throughout the group, together with the frequent difficulty of

obtaining material, makes their taxonomic use difficult. However there are a few genera in which this stage is distinctive and there are specific differences that make the study of the first stage important in any systematic investigation of the group.

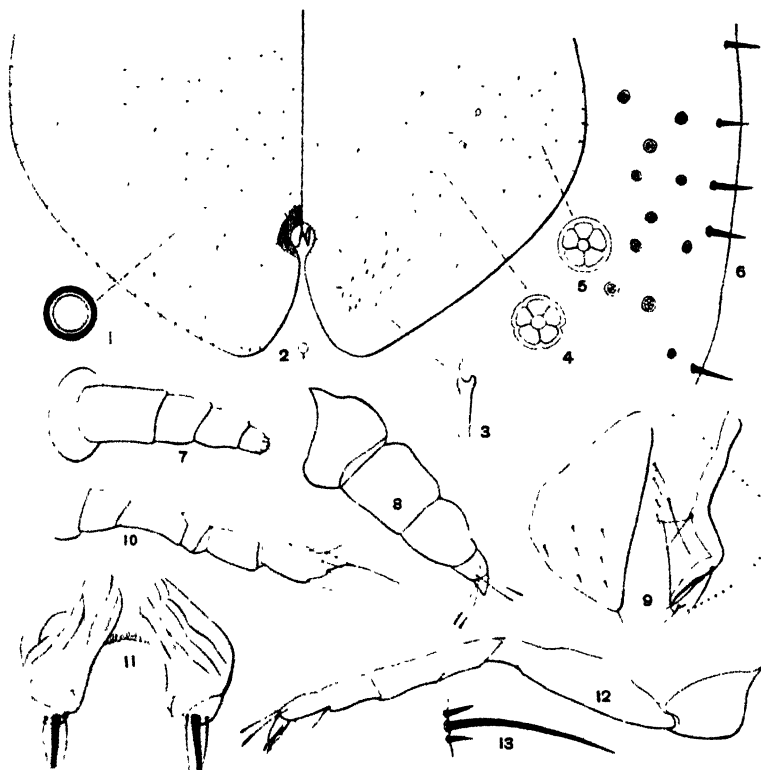


Fig. V. *Toumeyella mirabilis* (Ckll.). 1, tubercle-like pore; 2, posterior portion of body of adult female; 3, tubular duct; 4, 5, quinquelocular pores; 6, section of body margin of adult female with marginal and stigmatic setae; 7, antenna of adult female; 8, leg of adult female; 9, anal plates of adult; 10, antenna of first stage; 11, anal plates of first stage; 12, leg of first stage; 13, stigmatic seta of first stage.

STRUCTURE OF THE DERM.

As the adult female reaches maturity the derm usually becomes sclerotic and pigmented. This change sometimes takes place more or less uniformly over the dorsum, the venter remaining membranous. In other cases only a portion of the derm becomes sclerotic, as in *Toumeyella pinicola* where the

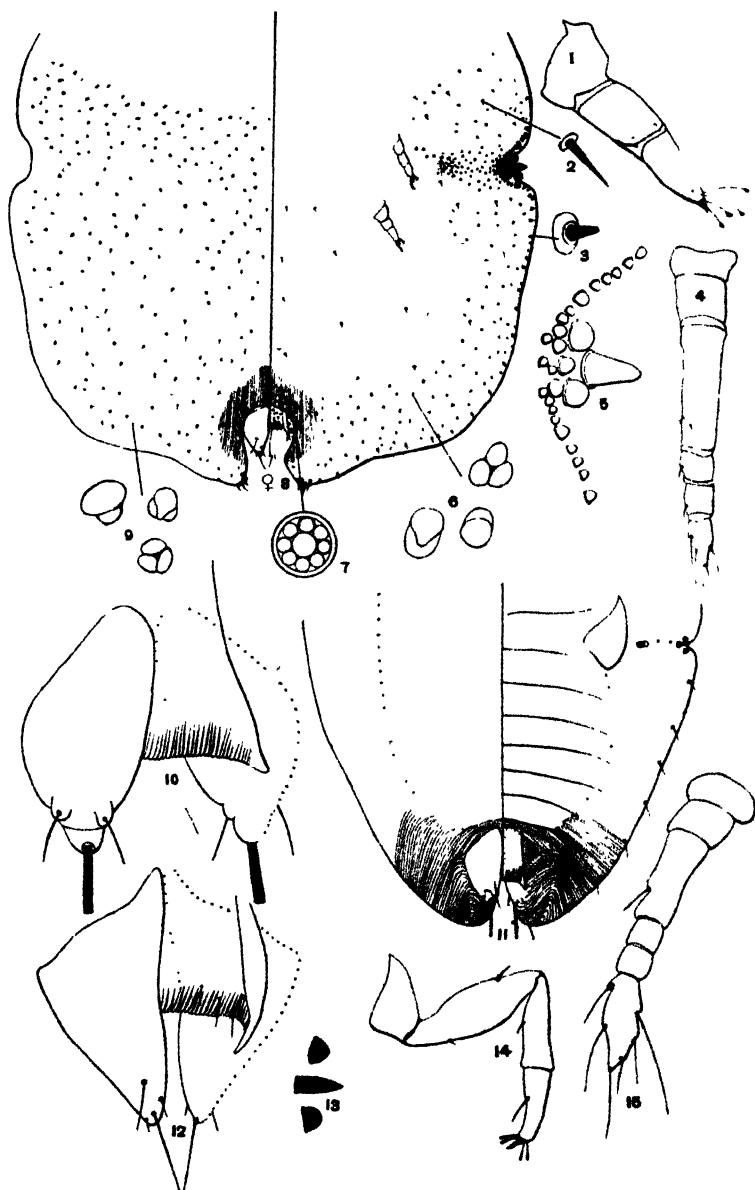


Fig. VI. *Ceroplastes rubens* (Maskell). 1, leg of adult; 2, body seta; 3, marginal seta; 4, antenna of adult; 5, stigmatic setae of adult; 6, irregular pores of adult; 7, multilocular pore; 8, posterior portion of body of adult female; 9, irregular pores; 10, anal plates of first stage; 11, posterior portion of body of first stage; 12, anal plates of adult female; 13, stigmatic setae of first stage; 14, leg of first stage; 15, antenna of first stage.

dorsum is membranous except for an area about the anal plates. In some forms the dorsal derm presents the appearance of having many small, cell-like translucent areas, this condition being especially marked in the three common species of *Saissetia*.

Histological sections show that in *Saissetia hemisphaerica* and in other species as well, this appearance is caused by a varying thickness of the derm, thick and heavily sclerotic areas alternating with thin areas, each of which bears a minute pore (Fig. III, 2), which is the opening of a gland. This condition is widely distributed and its value as an indication of natural relationships is extremely dubious.

In some forms, such as *Mallococcus* and *Eriopeltis*, the derm of the entire body remains membranous

PORES AND DUCTS.

No thorough investigation of the various wax-secreting glands of the *Coccoidea* has been made. The existing information is consequently very incomplete and the earlier workers mention little except the more conspicuous stellate stigmatic pores, disc pores and submarginal tubercles. Yet, without a doubt, a thorough understanding of these structures will be necessary for the attainment of a satisfactory classification of the group.

Such an understanding can be obtained only by means of a histological study of the structures that underlie these various kinds of pores and ducts and such a study, even for the *Coccidæ* alone, would be worthy of a monograph by itself. For this paper neither the time nor the material for such a study has been available. Consequently, only such information as can be gained from dermal preparations can be presented.

There appear to be three main types of pores and ducts

1. **Tubular ducts:** Gland openings through cylindrical ducts which bear a smaller prolongation at their inner end.
2. **Sessile pores:** Gland openings through a pore that is sessile in the derm.
3. **Submarginal tubercles:** Elevated tubercles surrounding a double central tube.

1. Tubular ducts.

Plate I, Fig. 31 represents a section through a gland of *Lecanium corni* (Bouche). The duct is divided into two parts; a basal portion of relatively large diameter, the inner end of which is reflexed to form a cup, and a distal portion which consists of a relatively very delicate tube that arises from the rim of this cup. The whole tube penetrates into the gland, the delicate tube entering the lumen into which the secretory cell of the gland pours its secretion. From the lumen the wax evidently passes as a fluid through the filament to the basal tube, and thence to the exterior of the body. Modifications of this type occur in other groups of the *Coccoidea*.

In Plate I, Figs. 1-27 are illustrations of the various forms of ducts found in the Coccid genera. There are differences in size, ranging from long, slender ducts, as in *Hemilecanium* (Fig. 3) and *Inglisia patella* (Fig. 5) to very small forms, as in *Toumeyella* (Fig. 17) and *Cardiococcus* (Fig. 19). The cup may be deep, as in *Ceroplastes* (Figs. 10, 11), or shallow as in *Saissetia hemisphaerica* (Fig. 15). The bottoms of the cups are usually rounded, but they may be cut squarely across, as in *Takahashia japonica* (Fig. 8) or *Lichtensia viburni* (Fig. 7). Some forms have cups that are symmetrical, as in *Pulvinaria* (Fig. 14) or *Saissetia hemisphaerica* (Fig. 15), while in others, as *Malloccoccus* (Fig. 12) and *Ceroplastes sinensis* (Fig. 4) the cups are asymmetrical. The inner filament may be very delicate, as in the small ducts of *Saissetia* (Fig. 18), moderately broad as in *Takahashia japonica* (Fig. 8), or nearly as large as the basal part of the duct itself in *Saissetia hemisphaerica* (Fig. 15) and *Ceroplastes sinensis* (Fig. 4).

In *Ceronema dryandra* (Plate I, 28) there occurs a peculiar type of duct which resembles the submarginal tubercles found in some forms and has been so called by Morrison, but its structure is nearer that of a typical tubular duct. It arises from a sclerotic plate that includes a smaller plate which bears a few stout setæ. The opening of the duct is in this smaller plate. The duct bears at its inner extremity a very delicate central filament. This type of duct occurs in a submarginal row around the body and is inter-set with a row of small tubercles of uncertain structure. The first stage of *Ceronema caudata* has ventral submarginal rows of this same type of duct.

Distribution of tubular ducts. All of the thirty-two genera of Coccidae studied possess tubular ducts except only those species which I consider to be true *Coccus*, *Eucalymnatus*, *Paralecanium* (not certain because of poor material), *Cryptostigma*, possibly some species of *Protopulvinaria*, *Lecanopsis brevicornis* and *Toumeyella numismatica*. The ducts occur on either the dorsal or ventral body surfaces, more often the latter, and sometimes on both surfaces in the same species. They are distributed around the anal plates, in submarginal ventral bands and sometimes in the anterior body region, and may be very abundant or only sparsely scattered over the body.

The nature of the secretions produced by the tubular ducts. In *Pulvinaria*, *Filippia* and *Eriopeltis* the tubular ducts seem to be responsible for the production of the ovisac. The bodies of the females of *Eriopeltis* are nearly completely enveloped by the ovisac and the tubular ducts, which occur abundantly on both sides of the body, seem to be correlated with it, for no other type of pore or duct is abundant. The tubular ducts of *Pulvinaria* occur in broad ventral submarginal bands upon the abdomen, which is the correct position for the formation of the ovisac in this genus and there seem to be no other pores from which the ovisac can possibly arise.

However, the presence of numerous tubular ducts does not assure the production of an ovisac, as is evidenced by the species of *Lecanium* and *Saisseta* in which numerous ducts are present in the same position as in *Pulvinaria* but which do not possess an ovisac. It can be concluded therefore that presence or absence of an ovisac depends upon physiological rather than structural peculiarities.

The use of the tubular ducts in taxonomy. The possibilities of use of any one structure throughout a group are limited, for a structure which is constant in one group may break down completely in another. One type of tubular duct may be constant throughout a genus, as in *Pulvinaria* which has a duct with a short basal tube of medium breadth surmounted by a shallow sclerotic cup and bearing a long, slender filament (Plate I, Fig. 14). In all the species that I consider to be true *Lecanium*, except *L. persicae*, the tubular ducts are rather short and stout with a shallow, bulging, non-sclerotic cup and a short, slender filament (Plate I, Fig. 13).

The only morphological characters that I have been able to find to separate *Pulvinaria* from *Lecanium* are this difference in the ducts and the presence or absence of a free tibio-tarsal articulation. In *Ceroplastes* there are at least two types of tubular ducts (Plate I, 4, 10) in the different species. In *Ceronema dryandra* there are three distinct types of tubular ducts, a condition that represents the extreme in the development of these structures. In general it may be said that the possibilities of taxonomic use of the tubular ducts are limited, but in some cases they are of considerable value, so that in a systematic study they may not be ignored.

Relation of the tubular ducts found in the Coccida to those found in other forms. In Plate I, Figs. 21-25 are drawings of several tubular ducts found in other groups. *Eriococcus* (Fig. 22), *Lecaniodiaspis* (Fig. 21), *Olliffiella* (Fig. 20) and *Kermes* (Fig. 23) have ducts of the same general type as those of the *Coccida*, that is with a cup and a filament arising from its rim. In *Kermes cockerelli* (Fig. 23) the shape of the ducts is peculiar, the cup being very deep and narrow, but it is essentially of the same type as the others. No special significance can be attached to this similarity of the ducts until other characters of the two groups have been investigated.

Pollinia ovoides (Fig. 25) and *Asterolecanium variolosum* (Fig. 24) possess crooked, irregular shaped ducts without true cups. The curve at one point may represent the further development of the condition found in the large tubular ducts of *Saissetia hemisphaerica* (Fig. 15) in which the filament has become so enlarged that the cup remains merely as a sort of thumb on one side.

2. Sessile Pores.

There are a number of distinct types in this group and a discussion of each will be given.

Multilocular pores. These are round pores (Plate II, 18, 19) with from six to twelve loculi and are found in nearly all the groups of scale insects. They are present in all the *Coccida* examined except *Ceronema*, *Cardiococcus*, *Pseudopulvinaria*, *Pseudophilippia*, *Neolecanium*, *Toumeyella numismatica*, *T. mirabilis*, *T. pinicola*, *T. pini* and *T. turgida*. They occur on the ventral side of the abdomen in transverse rows and around the anal region, except in *Takahashia japonica* where they are

scattered on both sides of the body and in *Lecanopsis brevicornis* where they occur along the margins of the body and to some extent on the dorsum. In the available specimens of *Physokermes*, broad bands of these pores have replaced the usual quinquelocular pores in the stigmatic furrows. The wide distribution and generalized location of these pores reduce them to usefulness only in specific classification. In the ovisac-producing species examined it hardly seems probable that these pores are responsible for the production of the sac, they being inadequate in numbers. When soft young adults of *Saissetia* or *Lecanium* are removed from their hosts, bands of white powdery wax are visible on the abdomen and around the anal plates, which probably come from these pores.

Quinquelocular or stellate pores (Plate II, 22). These are round pores with only five loculi which surround a central space, the whole having a stellate appearance. They occur in several groups of scale-insects and are found in all the species of the *Coccidae* that I have examined except in *Physokermes*, where they are replaced by multilocular pores. With a few exceptions this type of pore is confined to the stigmatic furrows and the region about the spiracular plates, as in *Hemilecanium imbricans*, or it may occur about the bases of the stigmatic setae as in *Malloccoccus*. In *Toumeyella*, *Neolecanium*, and *Pseudophilippia* these pores replace the multilocular type and extend over the venter of the abdomen.

The available species of *Cardiococcus* have a few ventral pores of this type around the anal region. *Exeretiopus longicornis* has narrow bands of large quinquelocular pores all around the body, in addition to the stigmatic bands. In *Pseudopulvinaria* there are such pores all over the dorsum.

I have seen no case in which these pores appear to be responsible for the production of the ovisac, so their only secretions are probably the powdery bands of white wax such as those which occupy the stigmatic furrows. The general appearance of these pores in the stigmatic furrows is nearly constant throughout the group. Exceptions to this condition may be utilized in classification. The species of *Toumeyella*, *Neolecanium* and *Pseudophilippia* are evidently related, on the basis of various characters, and this relationship is further indicated by the general distribution of these pores over the ventral side of the abdomen.

Round, tubercle-like pores (Plate I, 30). This type of pore presents a sclerotic ring surrounding a center with many perforations which in vertical section is more or less dome-shaped. I have found these pores only on the dorsum, where there is usually a group just cephalad of the operculum and sometimes a row along the mid-line of the dorsum.

They are present in a wide range of forms including *Saissetia*, *Pulvinaria*, *Lecanium*, *Neolecanium*, *Toumeyella*, *Cardiococcus*, *Hemilecanium*, *Eriopeltis*, *Philephedra*, *Paralecanium*, *Exuere-topus*, *Pseudophilippia* and *Takahashia juliscensis*. In *Toumeyella* they occur in a group just cephalad of the operculum, or scattered over the central portion of the dorsum or widely distributed over the posterior region of the dorsum. *Physokermes* has pores of this type scattered over the entire dorsum.

This type of pore is in general typical of this family, although it occurs also in some species of *Aclerda*, at least. I have looked for it especially in the Eriococcid and Asterolecaniid genera but have not found it there. As a generic character they are apparently of but secondary importance, but their number and distribution have proved useful for specific separation in a number of cases.

There is no obvious secretion from these pores and their function is doubtful.

Simple, round pores (Plate II, 23). This type of pore consists of merely a simple ring. It is usually somewhat smaller than the multilocular and quinquelocular pores and I have always found it on the dorsum, except in *Cardiococcus fossilis* where it is ventral. There are usually only a few of these pores scattered over the dorsum, as in *Coccus*, *Saissetia*, *Pseudopulvinaria*, *Luzulaspis*, *Lecanopsis brevicornis* and a few species of *Lecanium* and *Pulvinaria*. In *Hemilecanium imbricans* the dorsum is thickly beset with them, while in *Cryptostigma ingæ* there are two sizes of them, both with a heavy outer ring, scattered over the dorsum. *Cardiococcus fossilis* has small, round ventral pores which are most abundant in the marginal areas; occasionally two of these are approximate and form an 8-shaped pore. In *Malloccoccus* also, round pores and 8-shaped pores occur together and this suggests a possible origin of the latter type (Plate II, 4). Evidence as to the secretions from these pores is inconclusive.

The occurrence of a few of these pores is common to a number of genera and therefore only unusual abundance, as in *Hemilecanium* and *Cryptostigma*, or restriction in distribution as in *Cardiococcus*, is of taxonomic usefulness.

Eight-shaped pores. In the available material of this group I have found a number of species with 8-shaped pores of several types. I have classified these pores into five groups. I have also compared them with the pores of similar appearance in the *Asterolecaniids* and species.

1. Simple, without filament or tube (Plate II, 2). Very small pores having two equal halves which are separated by a narrow space and the centers of which are granulate. I have found this type of pore in *Cardiococcus fossilis*. It is apparently formed merely by the close approximation of two simple pores. A few pores of this type are present on the dorsum of the first stage of *Mallococcus sinensis*.

2. Simple, with tube. Very small pores having two equal halves with a granular appearance, separated by a narrow space and borne at the inner end of an invaginated tube. I have found this type of pore in two species. In *Mallococcus sinensis* (Plate II, 4) there are many scattered over the dorsum of the adult female. In the first stage of *Ceronema dryandra* (Plate II, 6) there are a number of such pores on the dorsum.

3. With a heavy outer ring, a sclerotic cross-bar and without a tube (Plate II, 3) I have found this type of pore only in *Takahashia jaliscensis*, in which they are small and scattered over the dorsum.

4. With a heavy outer ring, a sclerotic cross-bar and a tube (Plate II, 5). These are small pores borne at the inner end of an invaginated tube. I have found them only in *Pseudophilippia quaintancei*, where they are abundant on the dorsum and are probably responsible for the profuse cottony secretion which is characteristic of this species.

5. With the two parts of unequal size, separated by a narrow space and without a tube (Plate II, 1). The smaller part is granular in appearance and the larger has a heavily sclerotic ring surrounding the clear center. Sometimes the larger portion is divided into two parts, giving the pore a trilocular appearance. I have found this type of pore only in *Cardiococcus fossilis* and *C. (Inglisia) castilloæ*, where they are arranged in a single row along the mid-line of the dorsum from

the anal plates to the anterior margin of the head and also in a single row about the margin of the body.

The presence of 8-shaped pores has been regarded as the most distinctive character of the Asterolecaniids, so that any consideration of these pores as they occur in the *Coccidæ* must include a comparison of the two groups. In the Asterolecaniids (Plate II, 20) these pores are composed commonly of two equal parts separated by a space and not borne on an invaginated tube, this being the typical form. I have found no 8-shaped pores in the *Coccidæ* that are of exactly this character although those of *Cardiococcus fossilis* (Plate II, 1) bear some resemblance to this, but have two parts of unequal size and different structure. In *Cerococcus* (Plate II, 10) these pores are of a slightly different form. They are of varying size, are composed of two equal parts with heavily sclerotic outer rings, which are separated by a narrow space, and are borne at the inner end of a very short tube. In the available material of the *Coccidæ* I have found no pores of this form.

In the Asterolecaniid, *Callococcus pulchellus*, the adult female has 8-shaped pores with a sclerotic outer ring (Plate II, 17) and a cross-bar and borne at the inner end of an invaginated tube. In the first stage of this species the pores are of the same type except that they are slightly elevated (Plate II, 15) instead of invaginated. Morrison³ has represented these pores as bearing small filaments arising from their centers, but careful study with an oil immersion lens has not revealed such structures in the material that I have examined. The 8-shaped pores of *Pseudophilippia quaintancei* (Plate II, 5) are very similar to those of the adult of *Callococcus pulchellus*.

In *Eremococcus pirogallis* (Plate II, 16) there are 8-shaped pores with a sclerotic ring and a cross-bar, the whole enclosed within another ring and slightly elevated. Morrison has figured these as bearing delicate filaments but I have been unable to find these structures. However, in the first stage of three species I have found these 8-shaped pores with filaments and these are figured as follows, *Lecaniodiaspis tessellatus* (Plate II, 12), *Cerococcus quercus* (Plate II, 13), *Pollinia ovoides* (Plate II, 11).

³Morrison, H. Proc. U. S. Nat. Mus. 60: Art. 12: 32-5, f. 10, (1922).

The pores of *Takahashia jaliscensis* are very similar to those which occur in *Eremococcus*, except that they lack the outermost ring. The 8-shaped pores in *Lecaniodiaspis sardoa* and *Cerococcus bryoides* are slightly irregular in shape and seem to consist of two simple pores joined by a connecting membrane (Plate II, 9, 10).

In conclusion, it can be said that in the material examined I found no 8-shaped pores in the Coccidæ that were exactly the same as those in the Asterolecaniids, although no final conclusion can be drawn until these results have been checked by histological study of the exact structure of the glands.

In the Eriococcids examined, this including material of *Eriococcus*, *Kermes* and *Olliffiella*, I have found 8-shaped pores only in *Olliffiella cristicola* (Plate II, 8) which has such pores, of fairly large size, scattered over the dorsum. These seem to be composed of small pores arranged on an 8-shaped plate. I have seen no such pores elsewhere.

I have attempted to show that while 8-shaped pores occur in the Coccidæ, not all such pores are identical in structure and that various forms occur both in the Coccids and the Asterolecaniids. A final understanding and classification of these structures waits upon extended histological study. I have presented all that I have been able to learn from dermal preparations.

Pore plates. In a number of scale insects there occur pores which are aggregated into pore plates, to which the term *cribriform plates* has been applied.

In *Hemilecanium imbricans* (Plate II, 34) there are four large pore plates on the dorsum that are composed of an aggregation of many small pores with thick walls which are crowded together so closely that the whole has the appearance of a plate punched full of holes.

Inglisia patella (Plate II, 33) bears two large dorsal plates just cephalad of the anal plates, which are composed of many round or oval pores loosely grouped together.

Cryptostigma ingæ (Plate II, 32) bears a large, crescent-shaped pore plate dorsally at each stigmatic depression. These plates bear many small, multilocular pores and from each there arises in life a long pencil of wax.

Toumeyella numismatica (Plate II, 31) bears small pore plates consisting of from two to eight pores which seem to be

made up by the aggregation of separate, thick-walled pores. I have found such plates only in this species.

Several species of *Paralecanium* including *luzonicum*, *expansum* and *cocophyllæ* have cribriform plates on the venter of the abdomen, but the available preparations are too poor to permit study.

In *Lecanopsis brevicornis* and *L. formicarum* there is a large, circular plate surrounding each spiracle and bearing small, multilocular pores.

Miscellaneous pores. 1. Irregular pores (Plate II, 21, 26), made up of two, three or four parts and found thickly scattered over the dorsum of nearly all the species of *Ceroplastes* and around the ventral margin in several species of the same genus. These pores are probably responsible for the typical waxy covering of the species of this genus.

2. Trilocular pores (Plate II, 27, 29), which are dorsal pores found only in the genus *Ceroplastes*, egg-shaped as in *C. sinensis* (Fig. 27) or circular as in *C. irregularis* (Fig. 29). They are divided into three parts and the walls present the appearance of a Y. They replace, in *Ceroplastes sinensis* and *C. irregularis*, the irregular pores mentioned above and probably have the same function.

3. Trilocular, oval pores (Plate II, 28), which are small ventral pores, divided transversely into three parts. They are found in several species of *Ceroplastes*, usually forming marginal bands. I have found this type of pore only in *Ceroplastes* and regard it as typical of the genus.

4. Small round pores with duct (Plate II, 24) I have found these pores only in *Neolecanium herrerae*, where they are numerous on the venter. I have no information as to their possible occurrence in other species of this genus.

5. In *Coccus bicruciatatus* I found very small, round, thick-walled pores of uncertain structure, arranged in a double row of six groups along the mid-line of the dorsum. They are so small that I was unable to determine their structure.

3. Submarginal tubercles. (Plate 1, 29).

These are round tubercles surrounding a central invaginated tube and occur about the dorsal margin in a number of the *Coccidæ*. Their structure is peculiar, the derm being invaginated

to form a tube, which is reflexed to form a tube within the first, the innermost tube opening at the surface. They are usually quite large and in most forms there are from five to seven pairs. The following genera have pores of this type:

Coccus; occurring in nearly all species, fairly large, five to seven pairs.

Saissetia; small in *hemisphaerica* and *olca*, large in *nigra*, five to seven pairs in each species.

Lecanium; found only in *persica* and *corni* of the species examined. *L. persica* has twenty to twenty-five large tubercles. In material that has been referred to *L. corni* I have found these tubercles on specimens from the following hosts, *Quercus agrifolia*, *Q. lobata*, *Pasania densiflora*, *Pickeringia*, *Arbutus menziesii*, *Ceanothus*, willow, *Adenostoma* (tubercles occasional) and *Heteromeles* (occasional). In what may be regarded as typical *L. corni* they are lacking.

Pulvinaria; present in a few species, four to eight, rather small.

Hemilecanium imbricans; with many large tubercles set close together, thirty to thirty-five on each side of the body.

Ceronema dryandrae; without tubercles as here described but with large ducts, previously dealt with, which have been confused with these.

The secretion of these tubercles is in some cases at least a glassy thread. The tubercles are of no value in separating the four closely related and important genera, *Coccus*, *Saissetia*, *Pulvinaria* and *Lecanium*.

DIAGNOSES OF CERTAIN IMPORTANT GENERA.

Following a study of thirty-two important genera of the *Coccidæ*, I have drawn up a summary of the generic characters of the adult female and the first stage larva where the latter was available. I have attempted to arrange the genera in natural groups with, however, but little success. Thirteen of the genera can be aggregated into three groups, but the remainder seem to stand each by itself. A study of all the genera of the family may reveal relationships that will make attempts at grouping more successful, but from the material that I have worked with I can make no attempt to divide the family into subfamilies or tribes.

The three groups that I have been able to recognize are as follows.

1. *Coccus* and related forms including *Eucalymnatus*, *Lecanium*, *Proto-pulvinaria*, *Pulvinaria* and *Saissetia*.

2. *Toumeyella*, together with *Neolecanium* and *Pseudophilippia*.

3. *Exacretopus*, with *Paratairmairia*, *Philephedra* and *Luzulaspis*.

The remaining genera not included in these groups are arranged alphabetically.

1. The group of *Coccus*.

ADULT FEMALE: With or without ovisac; with well-developed legs and antennæ; with shallow stigmatic depressions bearing nearly always three stigmatic setæ; marginal setæ variable in form but usually more slender and shorter than the stigmatic setæ; anal region without hypopygial setæ. Pores and ducts as follows: (1) multilocular pores on the venter about the anal region and usually in transverse rows across the abdomen; (2) quinquelocular pores in the stigmatic furrows only; (3) submarginal tubercles occurring only in some species; (4) tubular ducts present except in *Coccus* and *Eucalymnatus*.

Genus *Coccus*, Linnaeus.

TYPE: *Coccus hesperidum* Linnaeus.

SPECIES EXAMINED: *acutissimus* (Gr.), *aequale* (Gr.), *bicruciatum* (Gr.), *caudatus* (Gr.), *frontale* (Gr.), *longulus* (Douglas), *mangifera* (Gr.), *viridis* (Gr.).

ADULT FEMALE: (Fig. II, 9) naked or covered only with a thin film of secretion; antennæ well-developed, slender, 6-8-segmented, third and fourth segments usually the longest; legs well-developed, without free tibio-tarsal articulation and with merely a transverse septum between the tibia and tarsus or with a small articular process, but apparently with no free movement of the joint (Fig. II, 5); anal cleft relatively short compared to the body length; anal operculum quadrate with cephalo-lateral and caudo-lateral margins equal or nearly so in length and forming rather sharp angles, with one or more small discal setæ near the apex of each plate; with no hypopygial setæ (Fig. II, 7); spiracles normal; marginal setæ variable, but always more slender than the stigmatic setæ; stigmatic setæ three, the middle usually longer than the other two; stigmatic depressions slightly indicated; tubular ducts apparently lacking; multilocular pores (Fig. II, 8) around the ventral anal region; quinquelocular pores in narrow bands in the stigmatic furrows; a few simple, round pores scattered over the dorsum; submarginal tubercles (Plate I, 29), present, 5-7 on each side of the body.

FIRST STAGE: (Fig. I, 4) with antennæ 6-segmented; legs normal; stigmatic setæ 3, with the middle one longer than the others; marginal

setæ short, small; body setæ lacking except near the base of each antenna and in the ventral abdominal region; anal plates not protruding beyond apex of body and not reticulated; quinquelocular pores present in stigmatic furrows; anal ring with 6 hairs. Material examined, *C. hesperidum* only.

NOTES: The generic characters of *Coccus* have never been well-defined and many species of uncertain relationships have been placed in the genus only because it was a convenient pigeon-hole. It has been separated from *Lecanium* by the flatness of the adult females, which are supposed to be at the most only slightly convex, but such a distinction is worthless.

I have tried to find some structural characters that can isolate the genus, and from the species studied I have been led to conclude that the apparent absence of tubular ducts, the small number of multilocular pores, the rather quadrate anal operculum and the character of the marginal setæ, which are usually rather short, pointed or moderately fimbriate, rarely broadly fimbriate, distinguish the true species of *Coccus*.

I would include *aequale*, *elongatus*, *frontale*, *hesperidum*, *longulus*, *pseudomagnoliarum* and *viridis* as typical species of the genus.

C. acuminatus and *C. mangifera* are closely related to *Protopulvinaria pyritormis* Ckll. and I would place them in the latter genus because of the similarity of body form, the long, narrow operculum, the deep anal cleft running far into the body and the short, broadly fimbriate marginal setæ.

C. acutissimus and *C. bicruciatu*s apparently do not belong in *Coccus*, but until I have more material available I will not attempt to relocate them.

Genus **Protopulvinaria** Ckll.

TYPE: *Protopulvinaria pyriformis* Ckll.

SPECIES EXAMINED: *P. pyriformis* Ckll., *Coccus mangifera* Gr., *Coccus acuminatus* Sign.

ADULT FEMALE: Broadly pyriform, more or less acuminate in front; body naked or with a very narrow fringe of cottony secretion; anal cleft long, extending nearly to the center of the body; operculum long and very narrow, the cephalolateral margins much longer than the caudolateral; antennæ long and slender, 7-8-segmented; legs long and slender; marginal setæ very short, broadly fimbriate, set very close together; stigmatic setæ 3, the middle one much longer than the others; stigmatic depressions slight; marginal tubercles 5-7 pairs; anal ring with 6 hairs.

NOTES: Cockerell separated this genus from *Coccus* by the presence of a narrow fringe of cottony secretion surrounding the body of the female after oviposition. This is not an ovisac, as in *Pulvinaria*, for the eggs are concealed beneath the body of the female. Green included his *longivalvatus* here for the same reasons. I would add the other species mentioned although they do not possess the secretion.

Genus **Eucalymnatus** Cockerell.

TYPE: *Lecanium tessellatum* Sign.

SPECIES EXAMINED: The genotype only.

ADULT FEMALE: Elongate, irregularly oval, broadly rounded posteriorly, narrower in front; dorsal area of mature individuals divided into many irregular plates in a roughly symmetrical pattern; in all other respects possessing the same characteristics as the genus *Coccus*.

NOTES: Cockerell established *Eucalymnatus* as a subgenus of *Lecanium*, and it was afterward raised to generic rank. It was established and has been maintained solely because of the striking appearance of the adult female due to the division of the derm into plates.

I have studied several young adult females before the hardening and tessellating of the derm had begun and when the structural characters could be clearly seen. I see no reason for maintaining the genus as distinct from *Coccus* or at the most as anything more than a subgenus.

Genus **Saissetia** Deplanches.

TYPE: *Lecanium hemisphaericum* Targ. (Fig. III).

SPECIES EXAMINED: *S. hemisphaerica* (Targ.), *oleæ* (Bern.), *nigra* (Nietner).

ADULT FEMALE: (Fig. III, 8) Body naked; derm of the dorsum at maturity becoming heavily sclerotic, with many thin areas that show as spots in dermal preparations; antennæ slender, 6-8-segmented; legs clear well-developed, tarsus with a conspicuous outward flexure and with a sclerotic articular process between it and the tibia, or tibia and tarsus separated by a simple transverse septum; anal cleft relatively short; operculum variable in shape, with a single large discal seta on each plate (Fig. III, 10); no hypopygial setæ; marginal setæ slender, pointed or moderately fimbriate at the apices, much more slender than the stigmatic setæ; stigmatic depressions slight, with three setæ of which the middle one is much the longest; spiracles normal; multilocular pores on the ventral side, grouped in the anal region and extending in transverse rows across the abdomen; quinquelocular pores confined to narrow bands in the stigmatic furrows; tubular ducts of two kinds,

both ventral, one with a small, short basal duct, a shallow, sclerotic symmetrical cup and a delicate inner filament (Fig. III, 1) the other a broad basal tube, a shallow cup and a filament which is nearly as broad as the basal duct (Fig. III, 5), this latter present only in *hemisphaerica*; tubercle-like pores (Plate I, 30) large, present on the dorsum just anterior to the anal plates in *oleæ* and *nigra*, not present in *hemisphaerica*; submarginal tubercles (Plate I, 29) 5-7 in each species.

FIRST STAGI.: Antennæ 6-segmented; legs normal; stigmatic setæ 3, the central one long, the others short; margin with short, slender setæ; no body setæ except near the antennæ and in the posterior ventral body region; anal plates not protruding beyond the apex of the body; stigmatic furrows with a few quinquelocular pores; anal ring with 6 hairs.

MATERIAL EXAMINED: *S. hemisphaerica*, *S. nigra*.

NOTES: This genus has usually been characterized by the convex form of the adult females and the clear areas of the derm, the latter character being regarded as definitive. This is misleading, however, for there are a number of species in the family that have this characteristic clearly developed but that do not belong to this group. *Saissetia* may be separated from *Pulexinaria* and *Lecanium* by the presence of the large discal setae on the anal plates, and by a different form of tubular duct.

Genus *Lecanium* Illiger

TYPE: *Coccus tilia* Linnaeus or *Coccus coryli* Linnaeus. *Tilia* is possibly a synonym of *coryli*, in which case *coryli* has priority.

SPECIES EXAMINED: *L. caryæ* (Fitch), *cerasorum* Ckll., *corni* (Bouche) *coryli* (L.) (= *caprea* (L.)), *discrepans* Gr., *excrecens* Ferris, *formicarii* Gr., *impar* Ckll., *nigrofasciatum* Perg., *opimum* Gr., *persica* (Fab.), *pruinatum* Coq., *prunastri* (Ponsc.).

ADULT FEMALE: Naked or at the most with a rather thin covering of powdery wax; antennæ well-developed, 6-8-segmented; legs well-developed, without a free tibio-tarsal articulation, the tibia and tarsus usually separated by a simple transverse septum; anal cleft relatively short; anal plates of no distinctive type, but without discal setæ; hypopygial setæ lacking; spiracles with no distinctive characteristics; marginal setæ variable in form, usually distinctly more slender than the stigmatic setæ but sometimes not so; stigmatic setæ 3, usually conical, the three subequal in length or with the middle one slightly the largest; multilocular pores ventral, grouped in the anal region and extending up the abdomen in transverse rows in some species; quinquelocular pores present only in narrow bands in the stigmatic furrows; tubular ducts (Plate I, 13) ventral with small, short basal tube, thin-walled cups and slender filament, (*persica* has ducts that are larger and with wide filament, resembling the larger ducts of *Saissetia hemisphaerica*); simple pores (Plate II, 23) are present in several species, scattered over

the dorsum; tubercle-like pores (Plate II, 30) occurring in several species in a group cephalad of the operculum or extending cephalad along the mid-dorsal line; sub-marginal tubercles present only in *persica* and *corni*; body setæ usually confined to 3 ventral pairs just cephalad of the anal region and 2 or 3 around the base of each antenna and occasionally short, conical setæ along the mid-dorsal line as in *L. corni*.

FIRST STAGE: Antennæ 6-segmented; legs normal; stigmatic setæ 3, equal or unequal; margin with short setæ; body setæ lacking except near antennæ and in ventral abdominal region; anal lobes sometimes protruding beyond apex of body, sometimes reticulate; stigmatic furrows with quinquelocular pores; anal ring with 6 setæ.

MATERIAL EXAMINED: *L. excrescens*, *formicarii*, *opimum*

NOTES: The absence of a free tibio-tarsal articulation and the characteristic tubular ducts are characters that seem to separate this genus from *Pulvinaria*. The anal plates lack the large discal seta of *Saissetia*.

Genus *Pulvinaria* Targioni-Tozzetti.

TYPE: *Coccus vitis* Linnaeus.

SPECIES EXAMINED: *P. acericola* (Walsh & Riley), *aurantii* Ckll., *bigeloviae* Ckll., *camelicola* Sign., *cupania* Ckll., *chrhorni* King, *flocilera* (Westwood), *mesembryanthemi* (Vall.), *occidentalis* Ckll., *peninsularis* Ferris, *psidii* Maskell, *rhois* Ehrh., *tinsleyi* King, *urbicola* Ckll., *vitis* (L.)

ADULT FEMALE (Fig. IV, 1): Naked until the beginning of oviposition, when a white, cottony ovisac is secreted from the ventral abdominal region, the body is often tilted up by the ovisac but is never enveloped by it; derm of the dorsum remaining membranous throughout life or, in most cases, becoming more or less sclerotic; antennæ well-developed, 6-8-segmented; legs well developed, with a free tibio-tarsal articulation, a heavily sclerotic articular process of the tarsus interlocking with the tibia (Fig. IV, 5); anal cleft relatively short; operculum of no distinctive form, without discal setæ; hypopygial setæ lacking; marginal setæ variable but always more slender than the stigmatic setæ; stigmatic depressions slight; stigmatic setæ 3, the middle one being considerably longer than the others (Fig. IV, 4); body setæ confined to 3 pairs of long ventral abdominal setæ and several between the bases of the antennæ; multilocular pores ventral, grouped in the anal region and in transverse bands on the abdomen; quinquelocular pores confined to narrow bands in the stigmatic furrows; tubular ducts large or small, with short basal tube, shallow, thick-walled, symmetrical cup and long, delicate filament, these are distributed in broad, sub-marginal, ventral bands; simple pores found on the dorsum of a few species; tubercle-like pores on the dorsum in several species; sub-marginal tubercles found in a few species, 4-8 pairs.

FIRST STAGE: Antennæ 6-segmented; legs normal; stigmatic setæ 3; margin with a few short setæ; body setæ lacking except near the base of each antenna and on the venter of the abdomen; anal lobes pro-

truding beyond apex of body or not and reticulated or non-reticulated; stigmatic furrows with a few quinquelocular pores; anal ring with 6 setæ. Material examined: *P. vitis*, *occidentalis* and an unidentified species.

NOTES: *Pulvinaria* has conventionally been separated from related genera by the presence of an ovisac in the adult female and earlier writers state that in structural characters there is nothing which will distinguish it from *Lecanium*. On the basis of the available material I believe that these two genera can be separated by the character of the legs and the tubular ducts, the free tibio-tarsal articulation and the form of the tubular ducts of *Pulvinaria* contrasting with the immovable division and a different duct form in *Lecanium*. The broad bands of ventral tubular ducts probably produce the ovisac in *Pulvinaria*, but in *Lecanium*, although the ducts are equally numerous there is no ovisac. It seems reasonable to conclude that the difference is physiological.

2 The group of **Toumeyella**.

To this group there belong three so-called genera, *Toumeyella*, *Neolecanium* and *Pseudophilippia*. Personally I regard these as constituting but a single genus, which might possibly be divided into subgenera.

ADULT FEMALE: Legs and antennæ greatly reduced but retaining their parts; anal plates very large, usually quadrate, with discal setæ; hypopygial setæ present; stigmatic depressions obsolete; marginal and stigmatic setæ small and inconspicuous or entirely lacking; stigmatic furrows with broad bands of quinquelocular pores, these pores also distributed over the venter to the anal region; tubercle-like pores numerous on the dorsum.

Genus **Toumeyella** Ckll.

TYPE: *Lecanium mirabilis* Ckll.

SPECIES EXAMINED: *Toumeyella cerifera* Ferris, *liriodendri* (Gmelin), *mirabilis* (Ckll.), *pini* King, *pinicola* Ferris, *turgida* Ckll.; *Neolecanium hererae* Ckll. and *N. imbricatum* (Ckll.); *Pseudophilippia quaintancei*: Ckll.; *Lecanium numismaticum* Pettit and McDaniel.

ADULT FEMALE: (Fig. V, 2) Naked, or with a thin, glassy test or with the dorsum thickly covered with cottony secretion; not secreting an ovisac except in the case of *T. cerifera*; tubular ducts small, present in small numbers around the anal region on the venter; quinquelocular pores (Fig. V, 2, 4, 5) extremely abundant, arranged as described for the group; tubercle-like pores more or less abundant on the dorsum, variously

arranged (Fig. V, 1, 2); in addition to these three types of pores special types occur in certain species as follows, simple pores (Plate II, 3) on the dorsum in the anal region of *pini* and *turgida*, multilocular pores on the venter in the anal region and in tranverse rows in *cerifera*; small pores borne at the apex of a short duct (Plate II, 24) in *herreræ*; 8-shaped pores (Plate II, 5) borne at the inner extremity of a duct in *quaintancei*; pore plates (Plate II, 31) in *numismatica*; anal ring with 6-8 setæ.

FIRST STAGE: Antennæ 5-segmented (Fig. V, 10); legs normal; stigmatic setæ 3, the middle one sometimes very long; marginal setæ few; body setæ few; stigmatic furrows with a few quiquelocular pores; other types of pores variable; anal ring with 6 setæ. Material examined: *cerifera*, *liriodendri*, *mirabilis*, *quaintancei*, *turgida* and an unidentified species.

NOTES: A complete understanding of the relationships of these species can only come with an examination of a wider range of forms, but I regard them as representing a single genus.

3. The group of *Exaeretopus*.

To this group there belong *Exaeretopus*, *Parafairmairia*, *Philephedra*, and *Luzulaspis*.

The female is long and slender; the derm remaining more or less membranous at maturity; antennæ and legs well-developed, the latter with free tibio-tarsal articulation; stigmatic depressions obsolete or vestigial; tubular ducts on both dorsum and venter, multilocular pores around anal plates and in abdominal rows.

Genus *Exaeretopus* Newstead.

TYPE: *Exaeretopus formiceticola* Newstead.

SPECIES STUDIED: *E. longicornis* (Gr.).

Adult female covered at gestation with a felted sac. In old females the posterior half of the abdomen is often sclerotic and minutely wrinkled. Antennæ long, 8-segmented; legs well-developed, with free tibio-tarsal articulation, anterior tarsus appearing dimorous because of an infolding in the derm; anal cleft relatively short; anal plates with no specially distinctive characters; hypopygial setæ absent; marginal setæ slender, trichiform; stigmatic setæ distinct from the marginal setæ or not so; stigmatic depressions obsolete; body setæ, small short, sometimes with longer trichiform setæ between the antennæ and in rows upon the ventral surface of the abdomen; tubular ducts of medium size, with very shallow cup which is barely indicated, so that the duct appears to be cut squarely across, filament delicate, the ducts numerous on both dorsum and venter; quinquelocular pores large, arranged in narrow lateral bands around the body and in narrow stigmatic bands; multilocular pores on the ventral side of the abdomen; tubercle-like pores small, a few along the mid-line of the dorsum.

NOTES: No material of the genotype, *E. formiceticola*, was available for examination and so I have been forced to rely upon the literature for information concerning this species. The genus was originally based upon the presence of the sac at maturity and the supposed dimerous condition of the anterior tarsi. Green has recently shown that this supposed condition of the tarsus does not hold, there being no actual articulation.

E. longicornis, which I have examined, agrees with Green's re-description of *formiceticola*, except that it lacks stigmatic setæ and the wrinkled, sclerotic condition of the abdomen, which appears in the adult female of the latter. I have therefore based my diagnosis of the genus principally upon *E. longicornis*.

Genus **Philephedra** Ckll. —

TYPE: *Pulvinaria ephedra* Ckll. The only included species.

SPECIES EXAMINED: The genotype.

ADULT FEMALE: Front part of the body in life covered by a thick square patch of secretion, posterior margin fringed with secretion and with irregular patches arranged in three longitudinal bands on the dorsum; antennæ very long and slender, 8-9-segmented; derm more or less membranous at maturity; anal plates with no distinctive features; marginal seta short, spake-like, set closely together; stigmatic setæ not distinct from marginal setæ and stigmatic depressions obsolete; body setæ few, a few small setæ near the bases of the antennæ and three pairs of longer setæ on the venter of the abdomen; multilocular pores, few, around the anal region and in transverse bands on the ventral side; tubercle-like pores present on the dorsum in considerable numbers and extending along the mid-line of the body; many tubular ducts on both dorsal and ventral sides of the body, but more on the dorsum and probably responsible for the patches of secretion; quinquelocular pores in narrow bands in the stigmatic furrows.

Philephedra ephedra is one of the largest forms in the family, reaching a length of 7-8 mm. and a width of 3-4 mm.

Genus **Parafairmairia** Cockerell. —

TYPE: *Fairmairia bipartita* Signoret. The genus includes only this and the following species.

SPECIES STUDIED: *P. gracilis* Gr.

NOTES: This genus was described as follows, "Scale divided into two portions, each with small grooves radiating from its apex, antennæ 8-jointed." This description is so incomplete that it is impossible to determine if *P. gracilis* is really congeneric with the genotype. It would be impractical

to attempt a definite diagnosis of the genus based upon a species as uncertain as is *gracilis*.

However, if *gracilis* really belongs with *Parasfairmairia*, this genus is a member of the *Exaeretopus* group. The genera will very probably require rearrangement when more forms are known.

Genus **Luzulaspis** Ckll.

TYPE: *Aspidiotus luzula* Dufour.

SPECIES STUDIED: *L. luzula* (DuFour), *L. australis* (Maskell).

ADULT FEMALE: Very long and slender, with the frontal area quite strongly produced; derm remaining membranous throughout and the body shriveling up to one end of the white, cottony ovisac; legs very long and slender, the tibia knobbed at the point of articulation with the tarsus; antennae slender, 8-segmented; anal plates small, with cephalo-lateral and caudo-lateral margins approximately equal in length, the mesal margins rough and bearing setae; marginal setae small, acicular or trichiform; stigmatic depressions obsolete or very slight; stigmatic setae 2 or absent; with long slender setae between the antennae and with or without median ventral groups on each abdominal segment; tubular ducts small, with very shallow cup, numerous on both dorsal and ventral sides and probably responsible for the sac that nearly or quite covers the body; multilocular pores on the ventral side in the anal region and in transverse rows; simple pores along the mid-line of the dorsum or widely distributed, nearly as large as the multilocular pores.

FIRST STAGE: Antennae very long, 6-segmented; legs normal; margin with trichiform setae; no body setae except between bases of antennae and in ventral abdominal region; anal plates not reticulate; quinquelocular pores in stigmatic depressions; anal ring with 6 setae.

NOTES: *Luzulaspis* is very close to the three other genera of this group. The only distinctive character that I could find is in the form of the anal plates, which in *Luzulaspis* are nearly quadrate in shape, with the inner margins rough and bearing setae. It is very doubtful that this is enough for the maintenance of the genus.

4. UNGROUPABLE FORMS.

Genus **Cardiococcus** Ckll.

TYPE: *Cardiococcus umbonatus* Ckll.

SPECIES EXAMINED: *C. fossilis* (Maskell) and *C. (Inglesia) castilloae* (Gr.).

ADULT FEMALE: In life covered with a brittle, waxy scale; legs and antennae either normal and well-developed or reduced; spiracles large and prominent; anal cleft very short and wide; anal plates small,

slender, apices pointed, with apical, discal, sub-apical and fringe setæ, the operculum surrounded by a sclerotic area; marginal setæ short, stout, spearhead-shaped; stigmatic depressions faintly indicated and with one short, stout, bluntly pointed seta which is considerably larger than the marginal setæ; tubular ducts present on the venter, small, with a deep cup; 8-shaped pores (Plate II, 1) present on the dorsum in a single row along the mid-line from the anal plates to the anterior portion of the head and interspersed with large, round tubercle-like pores; and also present in a row around the margin of the body; tubercle-like pores large, mingled with the 8-shaped pores along the dorsal mid-line; simple pores (Plate II, 2) both ventral and dorsal, occasionally two of them together forming an 8-shaped pore; quinquelocular pores in narrow bands in the stigmatic furrows and a few on the ventral side in the anal region.

NOTES: I have not seen *Cardiococcus umbonatus* Ckll., the genotype, but apparently *C. fossilis* (Maskell) is congeneric with this. *Inglisia castilloæ* (Gr.) seems certainly to be congeneric with *C. fossilis*. The rows of large 8-shaped pores and the stout spearhead-shaped marginal setæ are very characteristic of the genus.

Genus *Ceronema* Maskell.

TYPE: *Ceronema banksiæ* Maskell.

SPECIES EXAMINED: *C. dryandra* Fuller.

NOTES: The members of this genus have well indented stigmatic depressions with several blunt setæ accompanied by a sclerotic plate and have many very large tubular ducts around the body margin. These tubular ducts somewhat resemble the submarginal tubercles of other *Coccidæ* but are differently constructed. There are often several other types of tubular ducts in addition to these. Morrison⁴ has given a diagnosis of the genus to which I have nothing to add except the notes which I have previously given concerning these ducts and a figure of one of them (Plate I, 28).

Genus *Ceroplastes* Gray.

TYPE: *Ceroplastes jancirensis* Gray.

SPECIES EXAMINED: *C. albolineatus* var. *vulcanicus* Ckll., *ceriferus* (Anderson), *cirripediformis* Comstock, *cistudiiformis* Townsend and Ckll., *dugesii* Towns., *floridensis* Comstock, *irregularis* Ckll., *rubens* Maskell, *rusci* (L.), *scutigera* Ckll., *sinensis* Del Guercio.

⁴Morrison, H. Proc. U. S. Nat. Mus. 60: 60, (1922).

ADULT FEMALE: (Fig. VI, 8) Body completely covered by a dense, amorphous waxy mass of varying shape, but often marked off into distinct plates; in some species there are 4 well-defined stigmatic bands of white wax originating at the stigmatic depressions and extending part way over the waxy covering; derm strongly sclerotic at maturity; antennæ usually slender, 6-8-segmented and legs well developed but sometimes both are reduced as in *C. rubens* (Fig. VI, 1, 4); anal plates borne on an elevated, sclerotic tubercle, the plates small and narrow with the cephalo-lateral margins forming the cephalic margin of the operculum, discal setæ present; stigmatic depressions well-marked, with many conical or bullet-shaped setæ; marginal setæ usually very small and inconspicuous, blunt or pointed and at the most never prominent except in *C. scutigera*, which has conical setæ of the same size as the stigmatic setæ all around the body; body setæ few, occurring between the antennæ and in the ventral anal region; pores and ducts of several types present; tubular ducts (Plate I, 4, 10, 11) variable in form, a few found in some species both dorsally and ventrally, scattered or grouped around the anal and cephalic regions; irregular pores (Fig. VI, 8, 9), which are large pores made up of 2, 3 or 4 loculi and thickly scattered over the dorsum in nearly all the species and occurring ventrally around the margin in several, these probably responsible for the secretion of the test; trilocular pores (Plate II, 27, 29) which in *sinensis* and *irregularis* are thickly scattered over the dorsum, replacing the irregular pores in these species; trilocular oval pores (Plate II, 28) which are small ventral pores found in several species, usually forming marginal bands; multilocular pores found in all species examined grouped around the anal plates and sometimes in transverse rows on the venter of the abdomen; quinquelocular pores in wide bands in the stigmatic furrows.

FIRST STAGE (Fig. VI, 11): With 6-segmented antennæ; legs normal; abdomen sometimes with a reticulated band around the margin; without distinct stigmatic setæ or sometimes with 3 small rounded or conical stigmatic setæ; margin with small, slender setæ; anal lobes sclerotic; quinquelocular pores present in the stigmatic furrows; anal ring with 6 setæ. Species examined, *C. ceriferus* and *C. irregularis* and two unidentified species.

NOTES: *Ceroplastes* is a very distinctive genus. In the absence of material representing the type species I am relying upon the common interpretation of the genus.

Genus *Ceroplastodes* Ckll.

TYPE: *Lecanopsius dugesii* Signoret.

SPECIES EXAMINED: *C. acaciae* Ckll., *cajani* (Maskell), *dugesii* (Sign.).

ADULT FEMALE: With a glassy sac or test which is free from the body of the insect; antennæ 7-8-segmented, long and slender or reduced; legs well-developed; anal cleft very short relative to the length of the body; anal plates small, peculiar in shape, the anterior margins rounded and bulging, the apices slender and pointed; ventrally the segmentation

of the body is shown by deep folds; stigmatic depressions obsolete, the stigmatic setæ not distinct from the marginal setæ or sometimes represented by a single long, curved seta, marginal setæ short, stout, spearhead-shaped, set close together; tubular ducts occurring both dorsally and ventrally in broad marginal bands and probably producing the test; multilocular pores numerous on the ventral side around the anal region and in rows on the abdomen; quinquelocular pores in narrow stigmatic bands; anal ring with 6-8 setæ.

FIRST STAGE: Antennæ 6-segmented; legs normal; margin with short, stout, spearhead-shaped setæ; stigmatic setæ not distinct from the marginal setæ; body with a few small setæ on the ventral side near the antennæ and in the anal region; anal plates sclerotic; anal ring with 6 setæ; stigmatic furrows with a few quinquelocular pores.

NOTES: The characters as given are quite distinctive of this genus. The species treated seem all to be congeneric.

Genus **Cissococcus** Ckll.

TYPE: *Cissococcus fulleri* Ckll. The only species now included in the genus.

MATERIAL STUDIED: Somewhat fragmentary material of *C. fulleri*.

NOTES: This is the only member of the family *Coccida* that is a gall maker, the female forming a gall on the twigs of the host. The legs and antennæ are very small. The anal plates are narrow, bluntly pointed at the apices, with the lateral margins forming a continuous curve and with the dorsal surface beset with numerous small, stout setæ.

Ferris⁵ has dealt with this species from the same material that I have examined and I have nothing to add. The fragmentary condition of the material makes any very definite conclusions concerning anything more than the broad features impossible.

Genus **Cryptes** Ckll. and Parrott.

TYPE: *Lecanium baccatum* Maskell.

MATERIAL EXAMINED: Specimens of the genotype.

NOTES: The completely fused anal cleft of the adult female, the long, curved, blunt-tipped marginal and body setæ, the stout, very short, blunt stigmatic setæ of the first stage are sufficient to isolate this genus. Morrison⁶ has figured and described the species and I am unable to add anything to his discussion.

⁵Ferris, G. F. Can. Ent. 50: 112-3, Fig. 19, (1919).

⁶Morrison, H. Proc. U. S. Nat. Mus. 60: 80-83, Fig. 27, (1922).

Genus **Cryptostigma** Ferris.

TYPE: *Cryptostigma ingæ* Ferris, which is a synonym of *Pseudophilippia inquilina* Newstead.

SPECIES EXAMINED: *C. inquilina* and an undescribed species from Mexico.

NOTES: This distinctive genus has the legs reduced to the merest vestiges and retaining only the claw; the antennæ very small; the stigmatic depressions pronounced and each depression bearing a heavily sclerotic dorsal pore plate. Ferris carefully defined the genus in the original description and I have to add only a description of the pores and ducts as found in the genotype and an undescribed Mexican species.

Tubular ducts are apparently lacking; simple pores of two sizes and with a heavy outer ring are scattered over the dorsum; large multi-locular pores with 6-7 or occasionally 5 loculi are present on the venter around the anal region and in transverse rows on the abdomen; stigmatic pore plates (Plate II, 32) bearing many small multi-locular pores; tubercle-like pores present only in the unidentified species at hand, many in the mid-dorsal region of the body.

Cryptostigma ingæ is apparently identical with *Pseudophilippia inquilina* Newstead, but it has nothing to do with the genus *Pseudophilippia*. There is some question as to whether *Cryptostigma* is not synonymous with *Akermes*.

Genus **Ctenochiton** Maskell.

TYPE: *Ctenochiton viridis* Maskell.

SPECIES EXAMINED: *C. viridis* Maskell and *Lichtensia lycii* Ckll., which appears to belong to *Ctenochiton* rather than to *Lichtensia*.

ADULT FEMALE: Morrison⁷ has redescribed this genus and I shall here note merely the more important features as taken from his description. Adult more or less convex, usually very slightly so, covered in life with glassy, whitish or transparent wax plates; antennæ 6-8-segmented; legs normal; marginal setæ small, conical, set variably from very close together to some distance apart according to the species; stigmatic setæ single, large, strongly differentiated; dorsal setæ wanting or very small; ventral setæ few; derm with tiny tubular ducts and ventrally with two sizes of mutilocular pores; with or without other types; anal cleft short, the anal plates small; anal ring with 6 setæ.

FIRST STAGE: Antennæ 6-segmented; legs normal; stigmatic setæ occurring singly; marginal setæ small, slender; quinquelocular pores present in the stigmatic furrows; anal ring with 6 setæ.

⁷Morrison, H. Proc. U. S. Nat. Mus. 60: 71-4; Fig. 41, (1922).

NOTES: After a study of *Lichtensia lycii* Ckll. I have come to the conclusion that this species is a *Ctenochiton*. It differs from the typical character of the genus by having a large, almost spherical ovisac which covers the posterior end of the abdomen and rises partially from the dorsum instead of having glassy wax plates, and, unlike *C. viridis*, it has fringe setæ beneath the anal plates, but I believe there is close enough agreement in other characters to place it in this genus. It is certainly not a *Lichtensia*.

Genus **Eriopeltis** Signoret.

TYPE: *Eriopeltis lichtensteinii* Sign.

SPECIES EXAMINED: *E. coloradensis* Ckll., *E. festuæ* (Fonsc.).

ADULT FEMALE: At maturity enclosed within a white, felted sac, which is free from the body and leaves only the cephalic portion of the insect uncovered; derm remaining membranous throughout; antennæ and legs much reduced, antennæ 6-8-segmented, the legs with all parts present; dorsum beset with many short, stout truncate setæ; marginal setæ very small, conical; stigmatic setæ not distinct from the marginal setæ; stigmatic depressions obsolete; tubular ducts numerous, small, short, occurring on both dorsum and venter and probably responsible for the formation of the sac; tubercle-like pores arranged in a row along the dorsal mid-line; quinequilocular pores in narrow stigmatic bands; anal ring with 6-8 setæ.

FIRST STAGE: Antennæ 6-segmented; margin with short setæ; anterior end of the body with 8-10 short, stout, conical setæ, remainder of the body without setæ except about the bases of the antennæ and in the ventral abdominal region; anal plates protruding beyond the end of the body, somewhat reticulated; anal ring with 6 setæ.

NOTES: The genus *Eriopeltis* is very sharply defined by the truncate dorsal setæ which give its members the appearance of some species of *Eriococcus*. There is no other genus like it except the otherwise very different *Malloccoccus* and in this the dorsal setæ are sharply pointed.

Genus **Filippia** Targioni-Tozzetti.

TYPE: *Filippia oleæ* (Costa).

SPECIES EXAMINED: *F. oleæ* (Costa) and *Lichtensia viburni* (Licht.).

ADULT FEMALE: At maturity entirely covered by a white, fluffy ovisac which is a little longer than the insect itself; antennæ slender, well-developed; legs well-developed with a free tibio-tarsal articulation having a heavily sclerotic, tarsal articular process, tibia nearly twice as long as tarsus; anal cleft relatively short; anal plates broad, irregularly shaped, with the cephalo-lateral margins concave and the caudo-

lateral margins convex, the mesal margins rough; marginal setæ conical, pointed or chisel-shaped; stigmatic depressions slight and with 3 blunt setæ which are distinct from the marginal setæ, the middle one equal to or slightly longer than the other two; venter with several small setæ between the antennæ and with a number of fairly long setæ on the abdomen; tubular ducts (Plate I, 7) abundant on the dorsum and probably responsible for the production of the ovisac, medium sized, with a fairly deep, square-bottomed, thick-walled cup and a rather broad filament; multilocular pores on the ventral side in the anal region and in transverse bands on the abdomen; quinquelocular pores in narrow bands in the stigmatic furrows; anal ring with 6-setæ.

NOTES: After a careful study and comparison of *Filippia oleæ* and *Lichtensia viburni* I have come to the conclusion that these two species are congeneric. The essential characters of the two are the same. The disposition of the species of *Lichtensia* will be discussed under the latter generic heading.

Genus **Hemilecanium** Newstead.

TYPE: *Hemilecanium theobromæ* Newstead.

SPECIES EXAMINED: *H. imbricans* (Gr.), which has previously been referred to this genus.

NOTES: Specimens of the genotype are not available, nor have I had at hand the literature in which it is described. However, if *H. imbricans* (Gr.), which has been referred by other authors to this genus, be actually congeneric with *H. theobromæ* the genus is quite well marked.

Antennæ and legs long and slender, the former 9-segmented; legs without distinct tibio-tarsal articulation; tarsus with a rudimentary suture which gives it a 2-segmented appearance; anal cleft relatively short; derm about anal plates sclerotic; anal plates large, broad, lateral angles broadly rounded, apices sharply pointed; marginal setæ crowded closely together, long, spearhead-shaped; stigmatic setæ not distinct from marginal setæ, stigmatic depressions obsolete; body with a few small setæ, especially around the submarginal region, between the antennæ and in the perivulvar region; pores and ducts of several types: tubular ducts (Plate I, 3) long, narrow, scattered over the body on the ventral side and especially numerous around the body margin: cribriform plates (Plate II, 34) four on the dorsum, large, round made up of many thick-walled pores; submarginal tubercles (Plate II, 29) 30-40 on each side of the body; tubercle-like pores in a large dorsal group just cephalad of the anal plates; simple pores (Plate I, 25), very numerous on the dorsum; multilocular pores on the ventral side in the anal region and in transverse rows; quinquelocular pores in groups around each spiracle and in narrow bands in the stigmatic furrows.

Genus **Inglisia** Maskell.TYPE: *Inglisia patella* Maskell.SPECIES EXAMINED: *I. castilloæ* Gr., *chelonoides* Gr., *malvacearum* Ckll., *patella* Maskell.

NOTES: *Inglisia* is a peculiar genus which Morrison suggests stands alone. The body of the adult female is very irregular in shape with angular margins; a very short anal cleft; small, triangular anal plates; obsolete stigmatic depressions; marginal setæ of two types, tapering and slender alternating with stout and clavate; dorsal cribriform plates composed of many round pores loosely grouped together (Plate II, 33).

Morrison⁸ has described and figured *I. patella* Maskell and has given a diagnosis of the genus. He states that 11 species in addition to the type have been referred to the genus and that no one of these is congeneric with the type. I have studied specimens of three species, *castilloæ*, *chelonoides* and *malvacearum*, which have been referred to this genus and agree that none of these belongs to it. I would place *I. castilloæ* (Gr.) in *Cardiococcus*. I have at hand a single specimen of what is probably *I. malvacearum* Ckll. but on the basis of this inadequate material I can only say that it does not belong in *Inglisia*, and the same is true of *I. chelonoides* Gr., which I have represented by a single imperfect specimen.

Genus **Lecanopsis** Targioni-Tozzetti.TYPE: *Lecanopsis rhizophila* Targ.SPECIES EXAMINED: *L. brevicornis* Newstead, *L. formicarum* Newstead.

ADULT FEMALE: At maturity with a loose, cottony sac, or talc-like secretion or a glassy test; antennæ very much reduced, 6-7-segmented; legs very much reduced, short and stout but with all parts present; anal cleft relatively short; anal plates small, lateral angles moderately rounded, apices bluntly pointed; marginal setæ very short, pointed; stigmatic depressions obsolete and stigmatic setæ not distinguishable from marginal setæ; body setæ few, both dorsally and ventrally, minute; spiracles very large, set close to the body margin, with a circular pore plate surrounding each; multilocular pores large, with 7 loculi, distributed along the sides of the body and extending partially on to the dorsum; stigmatic pore plates large, circular surrounding the opening of each spiracle and bearing small, multilocular pores; simple pores numerous, scattered over the dorsum.

⁸Morrison, H. Proc. U. S. Nat. Mus. 60: 60-63; Fig. 20, (1922).

NOTES: The original description of this genus, as given by Targioni-Tozzetti was as follows; "Margin wide, with a deep anal cleft, anal lobes obtuse, approximate; antennæ short, conical, of 6 joints; mentum narrow; legs short, stout, tibiæ truncate and anteriorly grooved; tarsi ovate, acute." Newstead extended the characters of the genus to include *L. formicarum* Newstead, a species with 8-segmented antennæ and well-developed legs. Cockerell later added another species, *L. lineolata*, with 8-segmented antennæ and Maskell described another, *L. filicum* concerning which I have no information. Leonardi added *L. myrmecophila*, a species with 7-segmented antennæ and well-developed legs.

The original description of the genus is inadequate and in the absence of specimens of the type species it is impossible to be certain that all these species belong to the same genus. *L. brevicornis*, with its very much reduced legs and antennæ, seems to lie closest to the genotype and I have ventured to base a characterization of the genus upon it.

L. formicarum differs from *L. brevicornis* in having the legs and antennæ well-developed, tubular ducts present both dorsally and ventrally, multilocular pores on the ventral side in the anal region and in transverse rows and not distributed along the sides of the body. I am inclined to believe that it should be removed from *Lecanopsis*, although I am unable to place it in any other genus.

Genus **Lichtensia** Signoret.

TYPE: *Lichtensia viburni* Signoret.

SPECIES EXAMINED: *L. viburni* Sign., *L. lycii* Ckll.

NOTES: As I have pointed out earlier, I regard this genus as a synonym of *Filippia*. *L. lycii* I consider to belong to *Ctenochiton*. There are nine other species that have been referred to *Lichtensia* and these I can not place generically. They must for the present accompany their genotype into *Filippia*.

Genus **Mallococcus** Maskell.

TYPE: *Mallococcus sinensis* Maskell.

SPECIES EXAMINED: The genotype.

NOTES: This is an isolated genus with numerous large, conical setæ which are set in pits on the dorsum; with fairly

long, sharp marginal setæ and a single long, slender seta opposite each spiracle; 8-shaped pores on the dorsum and anal plates lobe-like and bearing rather long, stout setæ. It has been figured and redescribed by Morrison.⁹

As I have pointed out this genus resembles some of the Eriococcid forms and may indicate a relationship of the Coccids to the Eriococcids. It is a genus that must be studied carefully in connection with any consideration of the relationships of these groups.

Genus **Paralecanium** Cockerell.

TYPE: *Lecanium frenchii* Maskell.

SPECIES EXAMINED: *P. luzonicum* Ckll., *peradeniyense* Gr., *planum* (Gr.).

NOTES: The members of this genus are readily recognizable by the curious marginal setæ, which are modified into flattened and broadly expanded flabellæ. The stigmatic depressions are rounded incisions in the body margin with 3-4 short, blunt, stigmatic setæ. Morrison¹⁰ has redescribed the genus and I have only a description of the first stage to add.

FIRST STAGE: Antennæ 6-segmented, legs normal, stigmatic setæ 3, somewhat flattened; margin with a few very small setæ; body setæ between the antennæ and on the posterior portion of the venter; anal plates small, narrow, sclerotic; quinquelocular pores present in the stigmatic furrows; anal ring with 6 setæ. Species examined; *P. planum* (Gr.), *peradeniyense* Gr.

Genus **Pseudopulvinaria** Atkinson.

TYPE: *Pseudopulvinaria sikkimensis* Atk. (*Lefroyia castanea* Gr.).

SPECIES EXAMINED: *P. sikkimensis* Atk., represented only by fully adult material.

ADULT FEMALE: Enclosed within a felted sac; antennæ moderately long, 7-segmented; legs comparatively small, the femur short and thick, the tibia long and slender; anal cleft very short; anal plates narrow and slender, bearing a number of stout, rather long, setæ; anal ring with 6 setæ; stigmatic depressions obsolete and stigmatic setæ not distinguishable from the marginal setæ; tubular ducts few, present on the venter; quinquelocular pores rather large, numerous on the dorsum and probably responsible for the secretion of the sac; simple pores in small numbers present on the dorsum.

⁹Morrison, H. Proc. U. S. Nat. Mus. 60: 60, (1922).

¹⁰Morrison, H. Proc. U. S. Nat. Mus. 60: 78-80; Fig. 26, (1922).

NOTES: This is a peculiar genus that contains but a single species. Green has been inclined to place it near *Eriococcus* but it seems to me quite definitely Coccid. Only an examination of proper material representing various developmental stages will permit its definite placing. It is one of the forms that should especially be studied in connection with any discussion of the broader group relationships.

Genus **Physokermes** Targioni-Tozzetti.

TYPE: *Coccus piceæ* Schrank.

SPECIES EXAMINED: *P. insignicola* (Craw), *P. taxifolia* Coleman.

ADULT FEMALE: Body naked at maturity, almost spherical and with the derm heavily sclerotic; antennæ long and stout, 6-segmented; legs slightly to very much reduced, but with all parts present; anal cleft short; anal plates absent in the adult, being lost at the second molt; stigmatic depressions obsolete; no marginal or stigmatic setæ; body setæ in several transverse rows on the ventral side of the abdomen and between the antennæ; sometimes with a few setæ along the margin of the anal cleft; tubular ducts large, with deep angular cup, scattered on both sides of the body; tubercle-like pores (Plate I, 30) numerous, scattered over the dorsum; multilocular pores numerous on the venter about the anal region and in transverse rows, the stigmatic bands composed of smaller multilocular pores.

FIRST STAGE: Antennæ 6-segmented; legs normal; marginal setæ present, slender; stigmatic setæ not differentiated or represented by two short, slenderly conical setæ opposite each spiracle; long setæ around the bases of the antennæ, on the venter of the abdomen and sometimes in a double row extending along the mid-line of the dorsum; anal plates only slightly sclerotic, somewhat reticulated; quinquelocular pores present in the stigmatic furrows; anal ring with 6 setæ. Species examined: *P. concolor* Coleman and *P. taxifolia* Coleman, *P. piceæ* Schr.

NOTES: This genus includes the only *Coccida* in which the anal plates are lacking at maturity. All the known species occur on conifers and the group is undoubtedly homogeneous.

Genus **Takahashia** Cockerell.

TYPE: *Pulvinaria japonica* Ckll.

SPECIES EXAMINED: *T. jaliscensis* T. & W. Ckll., *T. japonica* Ckll.

ADULT FEMALE: At maturity forming, from the ventral side of the abdomen, a very long ovisac, which pushes the insect away from the host; antennæ somewhat reduced, short, stout, blunt, 7-segmented; legs reduced, without free tibio-tarsal articulation; anal plates longer than wide, cephalo-lateral margin longer than caudo-lateral margin, with broadly rounded lateral angles, apices rounded, mesal margins

rough, with discal, apical and fringe setæ which are all fairly long and stout; marginal setæ short, pointed, tending to appear spearhead-shaped; stigmatic depressions obsolete and stigmatic setæ not differentiated from the marginal setæ; a few very small setæ about the bases of the antennæ and on the venter; tubular ducts (Plate I, 16) numerous, with deep cup and broad filament, scattered over both dorsum and venter; multilocular pores large, numerous, scattered over dorsum and venter intermingled with the tubular ducts, both together perhaps producing the ovisac; quinquelocular pores confined to narrow bands in the stigmatic furrows.

FIRST STAGE: Antennæ 6-segmented; legs normal; margin with very fine setæ; stigmatic setæ 3, short, conical, equal in length; body setæ lacking except in the ventral abdominal region and about the bases of the antennæ; anal plate reticulate; anal ring with 6 setæ; quinquelocular pores in stigmatic furrows.

NOTES: This genus was originally based merely upon habit, the fact that the ovisac lifts the adult female entirely from the twig upon which it rests being regarded as significant. An examination of the two species *japonica* and *jaliscensis* shows clearly that they are not congeneric, although I have been unable to place the latter in any genus with which I am familiar. This species has large, well-developed legs; large, quadrate anal plates; stigmatic depressions with 2 short, blunt stigmatic setæ; many 8-shaped pores scattered over the dorsum (Plate II, 3); tubercle-like dorsal pores; tubular ducts of a type different from those of *japonica* and confined to the venter.

Genus **Vinsonia** Signoret.

TYPE: *Coccus stellifera* Westwood.

SPECIES EXAMINED: The genotype.

NOTES: Lack of proper material of this genus has prevented a study of the pores and ducts and I have nothing to add to the figures and description given by Green in the *Coccidæ of Ceylon*. The curious character of a distinct suture which separates the sclerotic cephalic apex of the body from the remainder is quite distinctive.

KEY TO THE GENERA PREVIOUSLY TREATED.

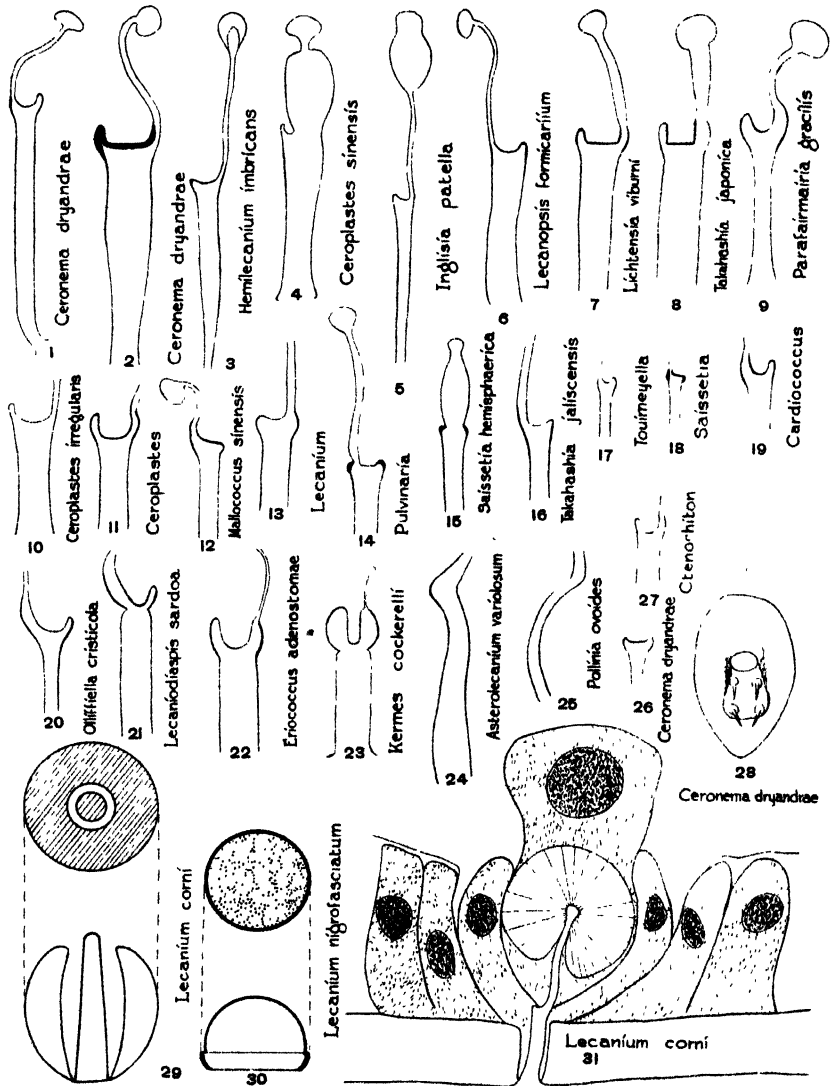
Previously existing keys to the genera of this family have been based wholly or in large part upon habit characteristics. An attempt is here made to present a key based wholly upon morphological characters. It considers only the adult female

and for its use properly prepared material of the early adult, taken before the derm has become sclerotic, is necessary. It must, unfortunately, be restricted to those genera which the author has been able to examine, this including only about half of the genera that have been named. It may serve, however, as an essay in aiding to reduce the study of these forms to a morphological basis.

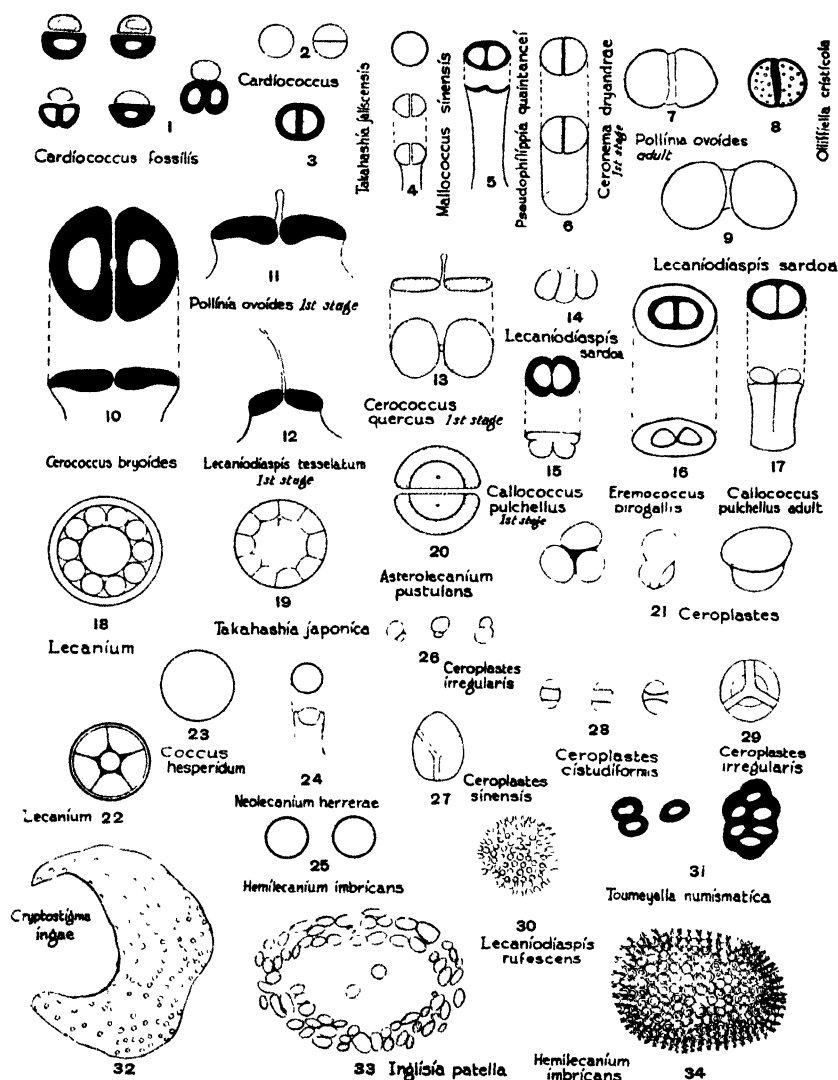
GENERIC KEY.

1. Adult female without anal plates *Physokermes* 2
 Adult female with anal plates..... *Eriopeltis* 3
2. Dorsum beset with stout, truncate setae..... *Eriopeltis* 3
 Dorsum not beset with such setae 3
3. Dorsum beset with stout, conical, pointed setae *Malloccocus* 4
 Dorsum not beset with such setae 4
4. Well-marked stigmatic depressions beset with many tubercle-like setae,
 anal plates borne upon a strongly sclerotic and more or less elevated
 process..... *Ceroplastes* 5
 Not so 5
5. Anal plates quite thickly beset with short, stout setae; plates narrow with
 the lateral margins forming a smooth curve without angles *Cissococcus* 6
 Anal plates not of this form 6
6. Anal cleft completely closed..... *Cryptes* 7
 Anal cleft not completely closed 7
7. Body irregular-shaped with angular margins, marginal setae of two kinds,
 tapering and slender, and stout and clavate, alternating; large, dorsal
 cribriform plates *Inglisia* 8
 Not so 8
8. Well-marked stigmatic depressions with several blunt setae accompanied
 by a sclerotic plate, tubular ducts of several types, including many very
 large ones around the body-margins, which resemble submarginal
 tubercles..... *Ceronema* 9
 Not so 9
9. With a row of large 8-shaped pores along the mid-dorsal line and around
 the body-margin *Cardiococcus* 10
 Without such 8-shaped pores..... 10
10. Long spear-head-shaped marginal setae, several large cribriform plates *Hemilecanium* 11
 Without such marginal setae or cribriform plates..... 11
11. Cephalic apex of body separated from rest of body by a distinct suture,
 and with a waxy test produced into seven rays, giving it a seven-rayed
 star appearance *Vinsonia* 12
 Not so..... 12
12. Marginal setae modified into broadly expanded and flattened flabellae *Paralecanium* 13
 Marginal setae not so modified..... 13
13. With many quinquelocular pores scattered over dorsum, narrow anal
 plates resembling somewhat Eriococcid anal lobes..... *Pseudopulvinaria* 14
 Not so..... 14
14. Many tubular ducts and multilocular pores scattered over the dorsum,
 antennae and legs small, reduced; marginal setae short, tending to be
 spear-head-shaped..... *Takahashia* 15
 Not so..... 15
15. Marginal setae very short, broadly fimbriate, anal cleft extending nearly
 into center of body, anal plates long and very narrow, antennae and
 legs very long and slender, body broadly pyriform..... *Protopulvinaria* 16
 Not so..... 16

16. With short, spear-head-shaped marginal setæ, stigmatic setæ not distinct, anal plates small, broadly rounded anteriorly with slender pointed apices; with very distinct segmentation on ventral side of thorax and abdomen. *Ceroplastodes*
Not so 17
17. Legs greatly reduced, retaining only the claw; very deep stigmatic depressions with a large, strongly sclerotic pore-plate at the base of each depression. *Cryptostigma*
Not so 18
18. Anal plates large, usually broad and quadrate-shaped with hypopigial and discal setæ, broad stigmatic bands of quinquelocular pores which usually extend down to and around the anal plates; marginal setæ lacking or small and inconspicuous. *Toumeyella*
Not so 19
19. Many multilocular pores along the sides of body, legs and antennæ short, very much reduced, with a circular pore plate surrounding each spiracle, apparently without tubular ducts *Lecanopsis*
Not so 20
20. Body long and narrow with long antennæ, large legs with free tibio-tarsal articulation, with many multilocular pores on the venter around the anal plates and transverse rows upon the abdomen, with many tubular ducts both dorsally and ventrally, anal plates with apical setæ. *Exaeretopus*, *Luzulaspis*, *Parafairmairia*, *Phlephedra*
Not so 21
21. With small, conical marginal setæ and a single large differentiated stigmatic seta opposite each spiracle; anal plates broad, tapering posteriorly with one or two apical and several discal setæ *Ctenochiton*
Not so 22
22. Marginal setæ of two types, chisel-shaped with a broad flattened apex, and conical, pointed; three blunt stigmatic setæ; anal plates broad, narrow anteriorly, broadly rounded posteriorly with the cephalo-lateral margins concave and the caudo-lateral margins convex. *Filippia*
Not so 23
23. Marginal setæ variable in form; linear, pointed or slightly frayed at apices; fairly stout spike-like, small trichiform, but always much more slender than the stigmatic setæ. Three well differentiated stigmatic setæ and narrow stigmatic bands of quinquelocular pores 24
24. Without tubular ducts and with only a few multilocular pores on the venter around the anal plates *Coccus*. (*Eucalymnatus*)
With tubular ducts in broad ventral submarginal bands, many multilocular pores around the anal plates and in transverse rows upon the abdomen 25
25. With a large, discal setæ on each anal plate, marginal setæ fairly long, either pointed or moderately fimbriate at the apices *Saissetia*
Without a large discal setæ on each anal plate, marginal setæ not always as stated above. 26
26. Legs without free tibio-tarsal articulation, with characteristic tubular ducts having short outer ducts, very round deep, thin-walled unsclerotized cups, and slender inner filaments *Lecanium*
Legs with free tibio-tarsal articulation, tubular ducts not of this type 27
27. Legs with free tibio-tarsal articulation, distinctive tubular ducts with short outer ducts, round shallow thick-walled cups which appear as sclerotized rings, and with long, slender inner filaments *Pulvinaria*



Tubular ducts of: 1, 2, *Ceronema dryandrae*; 3, *Hemilecanium imbricans*; 4, *Ceroplastes sinensis*; 5, *Inglisia patella*; 6, *Lecanopsis formicarium*; 7, *Lichtensia viburni*; 8, *Takahashia japonica*; 9, *Parafairmairia gracilis*; 10, *Ceroplastes irregularis*; 11, *Ceroplastes* sp.; 12, *Malloccoccus sinensis*; 13, *Lecanium* sp.; 14, *Pulvinaria* sp.; 15, *Saissetia hemisphaerica*; 16, "*Takahashia*" *jaliscensis*; 17, *Toumeyella* sp.; 18, *Saissetia hemisphaerica*; 19, *Cardiococcus fossilis*; 20, *Olliffiella cristicola*; 21, *Lecaniodiaspis sardoa*; 22, *Eriococcus adenostomae*; 23, *Kermes cockerelli*; 24, *Asterolecanium variolosum*; 25, *Pollinia ovoides*; 26, *Ceronema dryandrae*; 27, *Ctenochiton viridis*; 28, *Ceronema dryandrae*; 29, submarginal tubercle of *Lecanium corni*; 30, tubercle-like pore of *Lecanium nigrofasciatum*; 31, section through gland with tubular duct in *Lecanium corni*.



8-shaped pores of: 1, 2, *Cardiococcus fossilis*; 3, *Takahashia jalsiensis*; 4, *Malloccoccus sinensis*; 5, *Pseudophilippia quintancei*; 6, *Ceronema dryandrae*, first stage; 7, *Pollinia ovoides*, adult; 8, *Olfiffella cristicola*; 9, *Lecaniodiaspis sardoa*; 10, *Cerococcus bryoides*; 11, *Pollinia ovoides*, first stage; 12, *Lecaniodiaspis tessellatum* first stage; 13, *Cerococcus quercus*, first stage; 15, *Calloccoccus pulchellus*, first stage; 16, *Eremococcus pirogallis*; 17, *Calloccoccus pulchellus*, adult; 20, *Asterolecanium pustulans*. Trilocular pores of: 14, *Lecaniodiaspis sardoa*; 27, *Ceroplastes sinensis*; 28, *Ceroplastes cistudiformis*; 29, *Ceroplastes irregularis*. Multilocular pores of: 18, *Lecanium*; 19, *Takahashia japonica*. Irregular pores: 21, 26 of *Ceroplastes*. Simple pores of: 23, *Coccus hesperidum*; 25, *Hemilecanium imbricans*. Cribriform plates of: 30, *Lecaniodiaspis rufescens*; 31, *Toumeyella numismatica*; 32, *Cryptostigma ingae*; 33, *Inglisia patella*; 34, *Hemilecanium imbricans*.

NOTES ON METHODS OF REARING SARCOPHAGINÆ (DIPTERA), AND THE BIOLOGY OF SARCOPHAGA LATISTERNA PARK.*

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The literature of North American economic and medical entomology contains hundreds of references to the Sarcophaginæ, one of the subfamilies of the Sarcophagidæ. An investigation of these, in the cases where they deal with the immature stages, and in which the adult has not been reared, reveals that each is usually recorded as "*Sarcophaga* sp." There are but few cases, although the economic importance of the group is universally recognized, where notes on the larva have been preserved when the adult was reared. The writer has several times encountered larvæ of this subfamily while rearing parasites of Scarabæidæ, but has been unable to identify the species, except in those cases in which the reared *Sarcophaga* was a male. As a result of this difficulty, the present study was undertaken to secure an understanding of the habits and of the distinctive larval characters of the Sarcophaginæ or "flesh-flies." In this paper a few notes on the methods used in rearing Sarcophaginæ and on the biology of *Sarcophaga latisterna* will be given. The latter is the only species, among those of this subfamily which were reared by the writer, of which the larva has not been recorded and described either by Mr. C. T. Greene¹ or by Prof. F. M. Root.²

INSECTARY METHODS.

Adult female *Sarcophaga*, which were captured in the field, were kept separately in cages for from 4 to 5 days with an ample supply of ten percent honey solution for food. During

*Contribution No. 46 of the Japanese Beetle Laboratory, United States Department of Agriculture, Moorestown, New Jersey.

¹Greene, C. T. The puparia and larvæ of sarcophagid flies. Proceedings of the U. S. National Museum. Vol. 66, Art. 29, pp. 1-26, pls. 9. 1925.

²Root, F. M. Notes on larval characters in the genus *Sarcophaga*. Jour. of Parasitology 9: 227-229, pl. 1. 1923.

this period, attempts were made to induce the flies to place larvæ upon freshly killed insects. In many cases, the flies, although gravid, would not larviposit in the cages. The maggots were then dissected from the gravid female and were placed upon freshly killed *Popillia japonica* grubs. If the species was accustomed to feeding on insect tissue in the larval stage, the maggots fed rapidly and developed normally.

In this work, special cage methods were used to prevent outside contamination by larvæ of any of the common muscoid flies. Adults or larvæ of the sarcophagids were placed in tight, glass topped cages of 6 by 8 by 10 inches. All of these small cages were placed in a 40-mesh wire-cloth covered cage 7 feet long, 4 feet wide and 4 feet high. This made it nearly impossible for a female muscoid fly to introduce eggs or maggots into the inner cage. The larval food which was placed in the center of the inner cage, was kept in a tin can with sides almost 2 inches high.

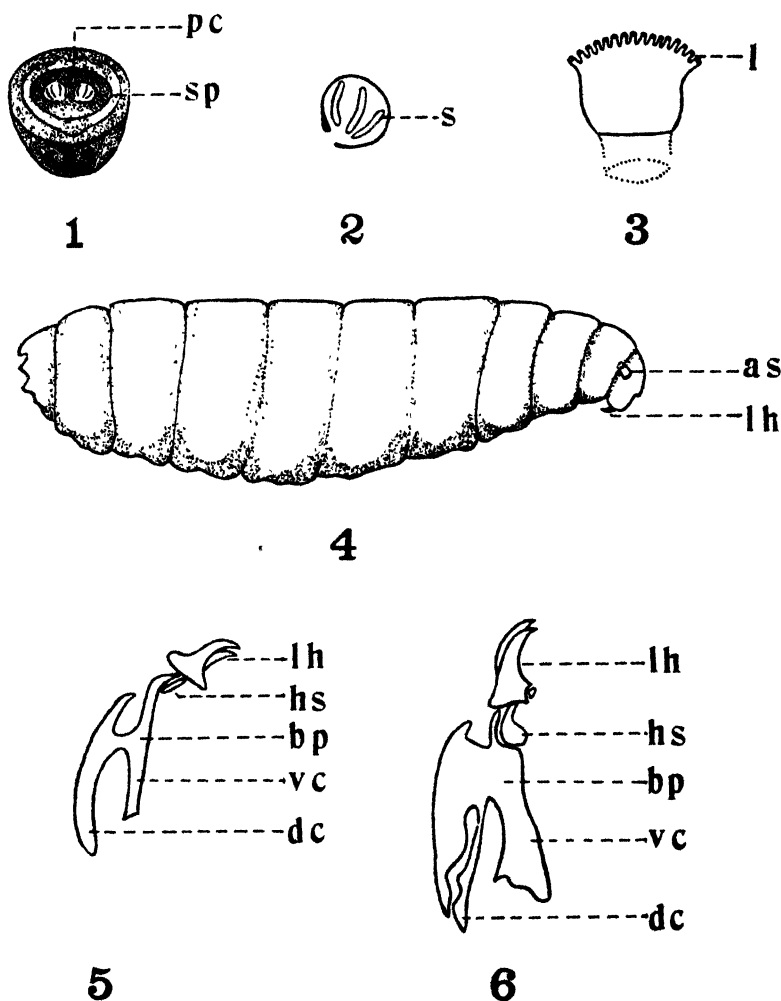
In every case, the progeny of a single female fly was kept in a single cage within the large cage. Specimens of first-stage and fully developed maggots were preserved for study. A large series of adults was reared from each female sarcophagid, all of which were carefully examined to be sure that only one species was present, and in no case was any contamination by muscoids discovered.

NOTES ON SARCOPHAGA LATISTERNA.

A large number of *Sarcophaga latisterna* were observed flying on October 1, 1926, around the larvæ of a species of *Anisota* (Lepidoptera) at Taunton Lakes in southern New Jersey. Nearly all of the *Anisota* larvæ at that time had ceased to feed on the oak leaves, and many had wandered to the edge of the road, where they had been killed by passing vehicles. Both the live and the dead *Anisota* larvæ were very attractive to those sarcophagid flies. The writer did not rear *Sarcophaga latisterna* as a parasite of *Anisota*. The closely related *Sarcophaga cimbicis*, which was numerous at the time *S. latisterna* was observed about the dead *Anisota* larvæ, was reared from adults of the rhinoceros beetle *Xyloryctes satyrus* at Jericho, Long Island, on September 2, 1927.

An adult female of *Sarcophaga latisterna* was captured from among those flying around the *Anisota* larvæ, and was kept

four days in a cage with plenty of food and freshly killed *Popillia japonica* grubs. As it did not larviposit upon the dead insects in the cage, numerous very active larvæ were



Sarcophaga latisterna.

- Fig. 1. Posterior end of third-instar larva. pc, posterior cavity; sp, spiracular plate.
 Fig. 2. Spiracular plate of third-instar larva. s, spiracular slit.
 Fig. 3. Anterior spiracle of third-instar larva. l, tubules.
 Fig. 4. Third-instar larva. as, anterior spiracles; lh, lateral hooks.
 Fig. 5. Buccopharyngeal apparatus of first-instar larva. bp, basal piece; dc, dorsal cornu; hs, hypostomal sclerite; lh, lateral hooks; vc, ventral cornu.
 Fig. 6. Buccopharyngeal apparatus of third-instar larva. Explanation of letters the same as for Fig. 5.

removed from it by dissection and were placed on freshly killed *P. japonica* grubs. The young sarcophagid larvæ developed very rapidly, and, after feeding for a period of 4 or 5 days, began to wander away from their food. On the following day they pupated at the bottom of the soil in the cage, and remained in this stage for one month. The shortness of their larval period may be compared with that of *Sarcophaga bullata*, in which it took 11 days for the larvæ to develop, from the time they began to feed until they pupated. It is apparent that *Sarcophaga latisterna* is able to complete its development on a very transitory food supply.

DESCRIPTION OF IMMATURE STAGES.

FIRST-INSTAR LARVA.—The larva is white, opaque, and without strongly pigmented contents. There are eleven segments, in addition to the head. The minute, light-colored chitinous spines on the cuticula are confined to the segmental lines. The spiny areas along the segmental lines are broader on the ventral side, and the ventral spines on body segments 2 to 6, inclusive, are dark colored. The articulated buccopharyngeal apparatus (Fig. 5) is equipped with two mandibular hooks. The basal piece of the pharyngeal skeleton consists of two lateral chitinized plates which are connected dorsoanteriorly. The mouth opening is located ventrally beneath the two great hooks. The larva is metapneustic, and the posterior spiracles are situated on two plates in a deep cavity just above the anal opening.

THIRD-INSTAR LARVA.—(Fig. 4). The larva, which is yellowish white, tapers to a point at the anterior end, is somewhat truncate at the posterior end, and slightly curved ventrally. Beginning with the second instar the larva is amphipneustic. There are eleven segments which are about equal in length, in addition to the head. The minute, chitinous spines on the cuticula are confined to the segmental lines. The posterior cavity (Fig. 1) is elliptical, nearly twice as long as wide, about as deep as the width at the surface, and lacks any well developed tubercles on its edges. The posterior spiracular plates (Fig. 2), which are at the bottom of this cavity, are separated by approximately one-third their width. Each plate has three slits converging at their base. The anal tubercles are very feebly developed. The articulated buccopharyngeal skeleton (Fig. 6) is equipped anteriorly with a pair of strong lateral hooks, and has a smaller, median hypostomal sclerite between the hooks and the basal piece. The basal piece of the buccopharyngeal skeleton consists of two lateral chitinized plates which are connected dorsoanteriorly by a curved, narrow band. Each lateral plate is incised deeply posteriorly, so as to form ventral and dorsal *cornua* in all stages of the larva. In the third-instar larva, the dorsal *cornu* is deeply incised posteriorly. There are two minute papillæ on each side of the head, which are just barely elevated. The anterior

spiracles (Fig. 3) each have 16-18 small tubules. In Mr. Green's key to *Sarcophaga* larvæ³ this species falls under couplet 4, and can be separated from *Sarcophaga bullata* and *Sarcophaga securifera* by the absence of well developed anal and posterior-cavity tubercles, as *Sarcophaga latisterna* has only a slight trace of these tubercles.

Length, 12-13 mm.; diameter, 3 mm.

PUPARIUM.—The medium to large sized, dull-reddish puparium of *Sarcophaga latisterna* was so well described by Mr. Greene⁴ that it will be unnecessary to give details here. As the anterior spiracles were missing in Mr. Green's material, this information may be added to his description; anterior spiracles arcuate, about three-fourths as high as wide; each spiracle with 16-22 yellow tubules, and the basal portion of the spiracle dark reddish.

Length, 6.7-9.5 mm.; width, 3.5-4 mm.

There is very little information in the literature about the habits of *Sarcophaga latisterna*. Dr. J. M. Aldrich states⁵ that he had a specimen which had been reared from *Pontia rapæ* by E. D. Brown. The adult fly emerged November 18, 1907, at College Park, Maryland. Phillips and King report⁶ that *Sarcophaga latisterna* was reared from *Heliothis obsoleta*.

CONCLUSION.

It may be concluded that the habits of *Sarcophaga latisterna* as well as those of some of its close relatives are plastic. Although they often develop as scavengers, they may be true parasites in some cases. It may be that what we observe is the parastic habit in the process of development.

The larvæ of the Sarcophaginæ show good specific characters, as far as they have been studied, and it is to be hoped that the work will be extended to include more species.

³Op. cit., p. 6.

⁴Op. cit., p. 18.

⁵Aldrich, J. M. *Sarcophaga and Allies in North America*, p. 77. Thomas Say Foundation Fund, Vol. 1, pp. 302, pls. 16. 1916.

⁶Phillips, W. J., and King, K. M. The corn ear worm: its ravages on field and suggestions for control. p. 12. U. S. Dept., Agri., Farmers Bulletin 1310, pp. 17, Fig. 18. 1923.

THE TRIBE PEMPHIGINI (APHIDIDÆ) IN UTAH.*

ASA C. MAXSON† AND GEORGE F. KNOWLTON.

Thecabius populi-monilis (Riley).

This aphid forms characteristic rows of bead-like cells, particularly on the upper sides of the leaves of narrow-leaved cottonwood, *Populus angustifolia*, and to a less extent on some of the wider-leaved species of poplars. The stem mother produces a gall similar to that formed by her young. These galls occur singly, usually between the midrib and the margin of the leaf. The first bead-like rows of galls are produced by the young of the fundatrix. Only a single individual is found in each cell.

According to Gillette, most of the second generation lice become winged and leave the galls, thus serving to scatter the species from tree to tree. A portion, especially of the later lice that are born, remain apterous, remain in the galls, and give rise to the third generation. These young, like the young from the stem mother, also migrate to the new leaves to continue the production of galls each of which harbors but one louse at first, but a portion of the young of this brood remain with the mother in the gall and become winged sexupara, of which 10 or 12 may be found in a single gall with the parent. Emergence of these sexupara begins about the first week of August and continues until the last of September; soon after emergence the sexupara give birth to the sexual forms.

On the narrow-leaved cottonwood, the galls are most commonly in rows, on one or both sides, and rather paralleling the midrib. On *P. balsamifera*, the rows may follow the margin, parallel the midvein, or run at different angles on different parts of the leaf. Sometimes three or four rows of galls will occur on the broad part of the leaf.

The stem mother usually has 5-jointed antennæ and is wingless. The winged individuals of the second generation

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emerge from the galls within a period of a few weeks. The mouth of the gall opens slowly, finally permitting the winged female to emerge. Predators frequently enter the opening galls and kill the pupal nymphs. Several species of syrphid larvæ and a small hemipterous insect were the forms most commonly observed in Utah.

Wingless females were numerous in the galls at St. George, on July 9, 1925. These had broad abdomens and contained many embryos. The antennæ of these females are 5- or 6-segmented; however, the last division of the antennal III is usually incomplete. In most cases at least one antenna is strictly 5-segmented, with no indication of a sixth.

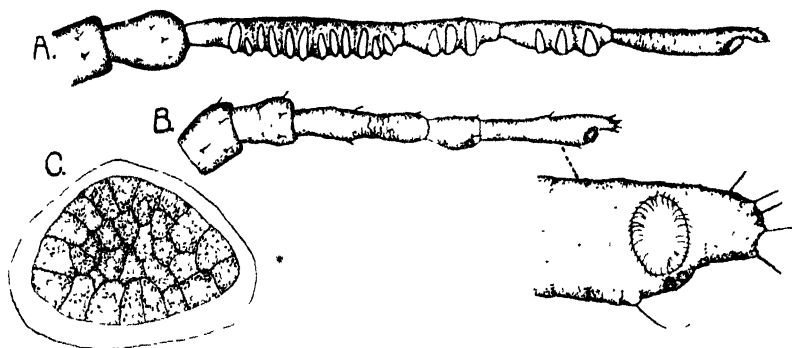


Fig. 1. *Thecabius populi-monilis* (Riley).

A, antenna of spring migrant; B, antenna of stem mother; C, wax pore plate from abdomen of stem mother.

This species has been collected in Utah from Blacksmith Fork Canyon, Cedar City, Eden, Farmington, Hyde Park, Murray, Logan, St. George, Salt Lake City, Santa Clara, and Smithfield.

***Thecabius populi-conduplifolius* (Cowen).**

This aphid folds the leaves of balsam poplar, *Populus balsamifera* and *P. deltoides*, producing a pseudogall along the midvein or parallel to it. The stem mothers may be found in galls near the margin of the leaf. The young of the stem mother do not remain in the gall with her, but migrate to the new leaves at the tips of the branches. All of the second generation become winged. They migrate to *Ranunculus* sp. where the third and several subsequent generations of apterous

viviparous females are produced. These summer colonies give a cottony appearance to the base of the *Ranunculus* leaves and stems. The fall migrants (sexupara) appear during late summer and fall and migrate back to the cottonwoods where the sexual forms are produced.

Galls of the second generation are always on terminal leaves. However, late in the season, after the stem mother ceases producing, new terminal leaves are produced which do not become infested.

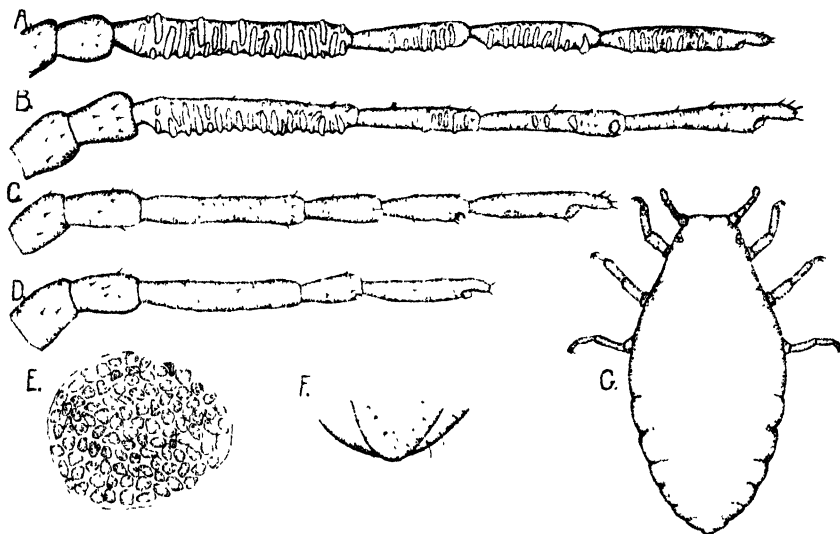


Fig. 2. *Thecabius populi-conduplicifolius* (Cowen).

A, antenna of spring migrant; B, antenna of fall migrant, C, antenna of apterous form from *Ranunculus* sp., D, antenna of stem mother; E, wax pore plate from abdomen of stem mother; F, caula and anal plate of spring migrant; G, oviparous female.

At Fruita, and along the stream below Capital Bridge, nearly all of the leaves on the young poplars were folded on June 27, 1926. By this time most of the aphids had migrated. Many of the aphids had been parasitized, but a few living specimens were obtained. These aphids were quite numerous in the galls at Randlett on July 14, 1927, and less so at the same time in the few collections made at Fort Duchesne and Vernal. Ordinarily, quite a number of aphids occur in each gall. When they were examined at St. George on July 9, 1925, only a few specimens remained in galls. Winged females were becoming abundant at Plain City, by June 15, 1928.

***Pemphigus populi-caulis* Fitch.**

Pemphigus populi-caulis and *Pemphigus populi-globuli* were described by Dr. Asa Fitch in the "Report of the Noxious and Other Insects of the State of New York," 1859.

Fitch's descriptions of the insects are too meager to make a separation of the species certain without the galls.

The gall produced by the aphid Fitch described as *P. p.-caulis* is described as a "bullet-like gall" on the middle of a leaf stalk from a Lombardy poplar. This gall was found on the 27th of June, three years before the description of *P. p.-caulis* was published.

Discussing the gall further, Fitch says: "When the leaves fell from this tree in autumn, a few were found among them, more faded than the others and having these same excrescences, but placed at the base of the leaf instead of on the middle of its stem"

Farther on in his discussion, Fitch states: "Galls analagous to those here described grow upon the leaf stalks of the Lombardy and Black poplar in Europe, from attacks of the *Pemphigus bursarius* of Linnaeus."

After comparing it with specimens of that species and its galls, Fitch considered his aphid different from *P. bursarius*, because of " . . . the fly being paler in its color, and its gall spirally coiled somewhat like the shell of a snail."

It is very evident from Fitch's discussion that he had in mind, when he described *P. p.-caulis*, a gall located on the petiole of the leaf at some distance from the leafblade, and one produced by a twisting of the petiole into a spiral.

It is quite probable that the petiole gall described by Fitch is not typical of *P. p.-caulis*, but that those at the base of leaf which he mentions as being taken in the fall are the typically located galls.

The aphid herein figured and described as *Pemphigus populi-caulis* is from galls located at the base of the leaf and produced by a twisting or spiralling of the petiole. The species described as *P. p.-globuli*, is considered to be the *globuli* of Fitch because of the likeness of its gall to the one described by Fitch in his discussion of that species.

Since the original descriptions of *P. p.-caulis* and *P. p.-globuli* were published these species have received much attention, if we may judge from the frequent references to both. However,

in spite of this, several aphidologists appear to have failed to distinguish between them.

P. p.-caulis and *P. p.-globuli* are very similar structurally and their galls are, in a general way, much alike, although quite different when studied in detail. This general similarity of both the aphids and their galls appears to have caused considerable confusion in the literature. This was probably increased by a lack of detail in the earlier descriptions.

In studying the two species under discussion, the senior author has collected material from several states and in many localities in some of these states. When collections of both species have been made in the same locality, they rarely have been found on the same host species. In Colorado and Utah *P. p.-caulis* was taken on *Populus deltoides* and *P. p.-globuli* on *Populus angustifolia* and *Populus balsamifera*. In California *P. p.-caulis* was taken on *Populus Fremontii* and *P. p.-globuli* on *Populus trichocarpa*. *P. p.-caulis* was taken on *Populus deltoides* at St. Cloud, Minnesota, and both species on *Populus balsamifera* at Oak Park, Minnesota. East of the Rocky Mountains in Montana *P. p.-caulis* was taken on *Populus deltoides* and *P. p.-globuli* on *Populus angustifolia*. *P. p.-caulis* was taken on *Populus balsamifera* in the Bitter Root Valley of Western Montana and *P. p.-globuli* on the same species of *Populus* near the Flat Head Lake. The junior author reports both species on *Populus balsamifera*. These observations appear to indicate that *Populus balsamifera* is the only common host of *P. p.-caulis* and *P. p.-globuli* east of the Rocky Mountains. *Populus trichocarpa* may serve as a host for both in the range of this tree.

These collections have been carefully separated according to the type of gall and a large series of the aphids from each gall type critically studied. These studies have brought to light certain structural differences by which *P. p.-caulis* and *P. p.-globuli* alate forms from the galls may be separated. These differences are constant in relative magnitude but not in actual magnitude.

Both species under discussion are quite variable in size and in some other characters. This necessitates studying several individuals and comparing the means of characters in order successfully to separate them. When a sufficient number of individuals to make a representative population is studied, separation becomes easy and certain.

The principal characters used by the senior author are: The number of sensoria on the antennal joints, the relative numbers of joints IV with less than 4 sensoria, and the antennal coefficient which is determined by the following formula:

$$\frac{\text{Length of III + IV + V + VI including spur}}{\text{Length of hind tibia}}$$

and the coefficient of antennal joint VI. This is determined by the formula,

$$\frac{\text{Length of joint VI + spur}}{\text{Length of joint III}}$$

Pem. populi-caulis and *Pem populi-globuli* are compared below by means of these characters.

Location	<i>P. p.-caulis</i>			<i>P. p.-globuli</i>		
	Antennal Coeff.	Coeff. of VI	Percentage of IV's with less than 4 Sensoria	Antennal Coeff.	Coeff. of VI	Percentage of IV's with less than 4 Sensoria
Montana	0 8657	0 7676	44	0 8171	0 8865	87
Minnesota.	0 9395	0 8283	52	0 7942	0 9550	83
Colorado	0 8718	0 8079	44	0 8382	0 9535	85
Utah	0 9719	0 8629	0	0 7759	0 9125	83
California.	0 9894	0 8263	9 8	0 7836	0 8331	85

In *Pem. populi-caulis* the antennal coefficient exceeds the coefficient of VI and the percentage of joints IV with less than 4 sensoria is always less than 60. A collection from Louisiana had 55 per cent. This is the largest percentage among collections from 9 states.

Pem. populi-globuli has the coefficient of VI greater than the antennal coefficient, the coefficient of VI greater than that of *Pem. populi-caulis*, and the percentage of joints IV with less than 4 sensoria always more than 60. Material from Idaho had 70 per cent. This is the lowest among collections from 6 states.

Thomas, in the "Third Annual Report on Noxious and Beneficial Insects of Illinois," 1879, pictures a typical *Pem. populi-globuli* gall for the gall of *Pem. populi-caulis*. Dr. O. W. Oestlund described *Pem. populi-caulis* in his synopsis of the Aphididæ of Minnesota. His description is not sufficiently

detailed to determine which of the two species under discussion he really had. The host is given as *Populus monilifera*. The length of antennal joint III and VI with the unguis, are given as the same. This makes the coefficient of VI, 1.0000. Collections of *Pem. populi-globuli* and *P. p.-venæ* have a coefficient of VI equal to or greater than 1.0000, but *P. p.-callis* never has a mean coefficient of this magnitude. Material collected from *Populus deltoides* at St. Cloud, Minnesota, in 1914 has an antennal coefficient of 1.0103 and a coefficient of VI of 0.6564. These were from typical *P. populi-caulis* galls. Another collection from *Populus balsamifera* made at Oak Park, Minnesota, had an antennal coefficient and of 0.9395 and a coefficient of VI of 0.8283. It appears that there may be some doubt of the identity of Oestlund's 1887 material.

E. O. Essig, in Pomona College Journal of Entomology, 1912 describes and illustrates *Pem. populi-caulis* and several galls. These galls are of 3 quite distinct types. One is typical of *Pem. p.-caulis*. Several are typical *Pem. p.-globuli* galls and one is typical of what the senior author is calling *Pem. p.-venæ*. The senior author has collected all three types of galls on *Populus trichocarpa* in California. The aphids from the typical *Pem. p.-globuli* and *Pem. p.-caulis* were the ones used in the studies already referred to. The ones from the other type of gall do not fit with either *Pem. p.-caulis* or *Pem. p.-globuli*. Several collections of these galls have been made in Minnesota. The aphids from Minnesota differ from the species being discussed in the same way as those from California. This species is described later as *Pem. p.-venæ*. The descriptions of Essig are not sufficiently detailed to enable one to determine his species with certainty. However, his figures of the antenna, of the alate viviporous female and the stem mother are typical of *Pem. p.-caulis*.

The California material in the senior author's collection is compared with that of Essig's below.

Most Frequent Number of Sensoria	<i>P. populi-caulis</i>	<i>P. populi-globuli</i>	Essig Material
III	10-11	9-10	10-14
IV	4-5	2-3	3
V	4-5	3-4	3-5
VI	6-7	4-5	7-8

It seems quite probable that Essig failed to separate the 3 species in his material. This appears to have given his species slightly different proportions and number of sensoria on the several antennal joints than typical California *Pem. p.-caulis*.

Dr. Edith M. Patch* described *Pem. populi-caulis* from *Populus balsamifera* and pictures 1 typical *Pem. populi-globuli* gall and 2 not typical of this species or of *Pem. populi-caulis*. The latter are similar to galls taken by the senior author at Oak Park, Minnesota, produced by what he calls *Pem. populi-vena*.

Dr. Patch pictures the antenna. This shows joint VI to be the same length as III. This is not typical of *Pem. populi-caulis*. The senior author has examined material from the collection used in Dr. Patch's work and from the typical *Pem. populi-globuli* gall figured in Bulletin 213. This material is typical *Pem. populi-globuli* having an antennal coefficient of 0.9719, coefficient of VI, 1.0000 and 83.3 per cent of joints IV with less than 4 sensoria.

There seems to be evidence that Dr. Patch also was working with *Pem. populi-globuli* and the form being called *Pem. populi-vena* and not *Pem. populi-caulis*.

Pemphigus populi-caulis.

DESCRIPTION.

Fundatrix:

Color.---Greenish to whitish green.

Wax pore plates; normal for the genus; head, none; prothorax, 4; meso- and meta-thorax and abdominal segments I to VI each with 6; segment VII, 2. Marginal plate usually the largest.

Dimensions.---Total length, about 3.39 mm.; width, about 2.08 mm. Relative length of antennal joints; I, 4.5; II, 4.5; III, 10; IV, 6. Joint III club-shaped, the distal portion about half greater in diameter than joint IV. Permanent sensoria on III and at base of poorly defined spur on IV fringed with cilia. There is a somewhat oval, clear area at a point about two-thirds the way from the base of III. Joints III and IV weakly imbricated. Imbrications bear small tubercles which terminate in a small spine. A few rather large more or less curved hairs on tubercles on all joints.

Relative length of fore femora, 23; tibia, 18; tarsi, 8.5; middle femora, 24.5; tibia, 20.5; tarsi, 8.5; hind femora, 32; tibia, 30; tarsi, 10.

*Maine Expt. Sta. Bul. 213, 1913.

Fundatrigenia (Summer migrant).

Color.—After exposure to the light the living insect has a bluish tinge due to a covering of fine whitish powder. The head and thorax are dark, almost black; the abdomen is a yellowish or yellowish-green; the antennæ and legs are dusky brown; the posterior margin of the stigma is dusky; the wing veins are slightly dusky to brownish.

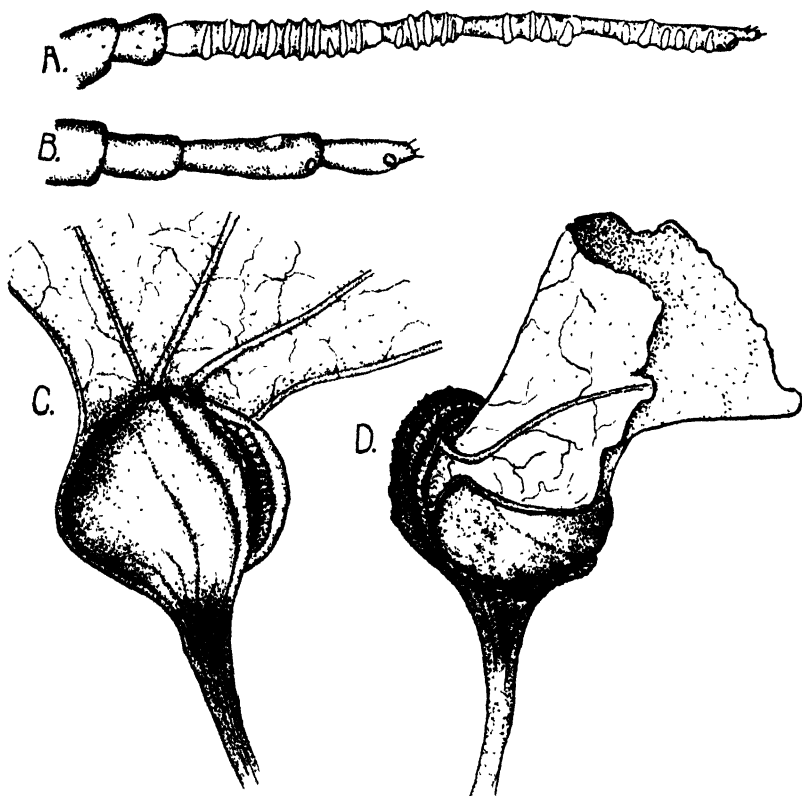


Fig. 3. *Pemphigus populi-caulis* Fitch.

A, antenna of spring migrant, B, antenna of stem mother;
C and D, galls on poplar.

The venation is normal for the genus. First and second discoidals of the forewing normally with their bases distinctly but not widely separated, frequently united. Basal one-fourth to one-third discoidal obsolete. Stigmal vein curved, well developed. Diagonals of hind wing normally arising from nearly the same point. Rarely with bases widely separated.

Dimensions.—Total length about 1.9 mm. Abdomen about 0.69 mm. wide. Forewing about 2.60 mm. long, width about 0.95 mm. Stigma about 0.60 mm. long and 0.17 mm. wide at point where stigmal

vein is attached. Hind wing about 1.80 mm. long and 0.50 mm. wide at widest point.

Antennæ 6-jointed. Sixth joint with a short unguis. Joints III, IV, V, and VI with transverse secondary sensoria annular. Sensoria rarely encircling the joints. Permanent sensoria at distal extremity of V and at base of unguis on VI more or less oval, surrounded by a fringe of cilia. Joint III with 9-13 sensoria, most frequently 10-11; IV with 3-5, most frequently 4; V with 3-5, most frequently 4; VI with 4-7, most frequently 7. Antennal coefficient larger than coefficient of joint VI; percentage of joints IV with less than 4 sensoria less than 60*.

Relative length of antennal joints.—I, 3.5; II, 3.5; III, 13.0; IV, 6.0; V, 6.5; VI, 10.5. The length of the antennal joints are quite variable even in the case of the two antennæ of a single individual.

Relative length of fore femora 24, tibia 28, tarsus 8; middle femora 20, tibia 28, tarsus 8.5; hind femora 26, tibia 38.5, tarsus 9.5. In all collections there are apt to be a few quite small individuals. The measurements given are those of a normal sized specimen.

The Gall.—The gall is semi-globular. Large ones attain a diameter of $\frac{1}{2}$ inch or more. Normally located galls are at the base of the leaf where the blade and petiole unite. The gall is composed of the thickened and twisted petiole and a very small portion of the base of the leaf blade which frequently extends a short distance down onto the gall. The greater part of the gall extends below the plane of the leaf blade. Viewed from above the mouth is normally not visible and the midrib and the first diagonal veins on either side are seen to merge into the body of the gall.

When viewed from below the midrib is seen to bend abruptly and to merge with a ridge formed by the edge of the petiole which follows the curve of the gall and forms a part of one lip of the opening. The other lip of the opening is formed by a fold in the base of the leaf blade for a part of its length and the balance by the edge of the petiole. The petiole is twisted so that the flattened portion lies in nearly the same plane as the leaf blade instead of at right angles to it as in normal leaves. It is clear that almost the entire gall is made up of the much enlarged and twisted petiole. The mouth is usually full-lipped and extends more or less in a spiral fully $\frac{3}{4}$ the distance around the gall. Many times there is a small round opening at some point along the lips through which the winged lice escape. The senior author has collected aphids which correspond in every respect to *P. p.-caulis*, from galls similar to those produced

*The material described was collected, in 1913, at Salt Lake City.

by *P. p.-venæ*, at Oak Park, Minnesota, and in the Bitter Root Valley in Montana. These were from *Populus balsamifera* trees heavily infested with *P. p.-globuli* and *P. p.-venæ*. It seems that under certain conditions at least *P. p.-caulis* produces galls on the leaf similar to those produced by *P. p.-venæ*.

This aphid was very abundant in Logan during the spring of 1925. The infestation was so severe that by July 1st many leaves had fallen from the infested poplars, *Populus balsamifera* and *P. deltoides*. About 3 per cent of the leaves remaining on the trees were infested with galls.

The aphids are ordinarily very numerous in these galls, and sometimes a hundred or more pupal nymphs and winged females in addition to the stem-mother are present in a single cell. Ordinarily, there is a large drop of liquid in the bottom of the gall. The waxy material secreted by the wax glands makes the inside of the gall grayish so that when it is opened, the moving aphids appear to be mixed up in a growth of fungus.

In addition to being present in Logan, this aphid was also found in Big Cottonwood Canyon, Utah, on June 29, 1925, where it was producing its characteristic galls. It has also been collected at Hyde Park during early July, 1928.

***Pemphigus populi-globuli* Fitch.**

DESCRIPTION.

Fundatrix:

Color.—Pale yellowish-white when mature. Antennæ, coxæ, legs, second and third joints of beak brownish. Tip of beak brown.

Wax pore plates normal for the genus; head, none; prothorax, 4; meso- and meta-thorax and abdominal segments I to VI, each with 6; segment VII, 2. Marginal plates and those on segment VII larger than the others.

Dimensions.—Total length about 2.5 mm.; width about 1.9 mm.; relative length of antennal joints: I, 3.5; II, 3.5; III, 8; IV, 6.5. Joints III and IV faintly imbricated. Imbrications consist of slightly raised ridges bearing rows of very small spines on tubercles. A few large curved hairs on at least III and IV. Permanent sensoria on distal extremity of III and at base of the weakly defined spur on VI fringed with cilia. Relative length of fore femora, 17.5; tibia, 15.0; tarsus, 7; middle femora, 20.5; tibia, 18; tarsus, 7; hind femora, 29.0; tibia, 26; tarsus, 8.

Fundatrigenia (Summer migrant).

Color.—The entire insect is lightly dusted over with a whitish powder which gives it a bluish tinge. Head and thorax dark, almost black. Abdomen greenish-yellow. Antennæ, coxæ, and legs dusky brown.

Posterior margin of stigma with a broad dusky band. Wing veins slightly dusky to brownish.

The venation is normal for the genus. The first and second discoidals of the forewing with bases normally widely separated, very rarely arising from nearly the same point. Basal one-fourth to one-third of third discoidal obsolete. Stigmal vein curved, well developed. Diagonals of the hind wing normally with bases widely separated; rarely arising from nearly the same point.

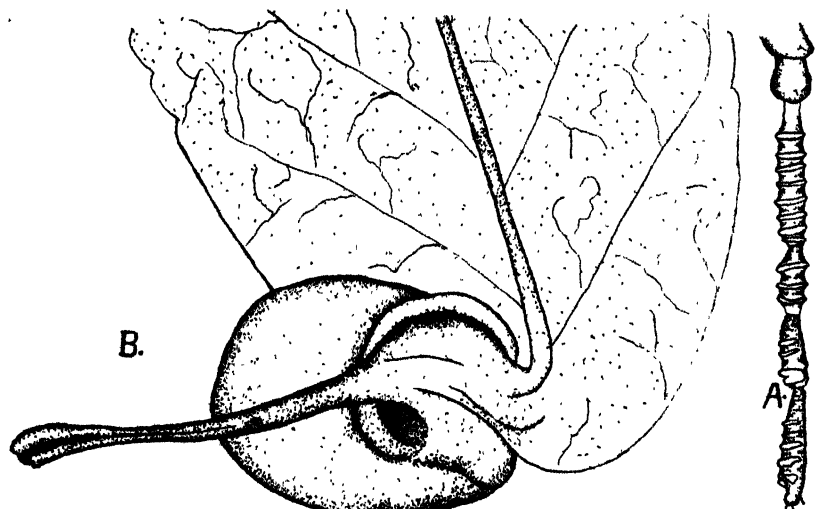


Fig. 4. *Pemphigus populi-globuli* Fitch.

A, antenna of spring migrant; B, gall on narrow-leaved cottonwood.

Dimensions.—In most collections a few small specimens occur. The following measurements are for average individuals. Total length about 1.83 mm.; abdomen about 0.7 mm. wide. Forewing about 2.61 mm. long and 0.95 mm. wide. Hind wing about 1.8 mm. long and 0.54 mm. wide at widest point. Stigma 0.53 mm. long and 0.19 mm. wide at point where vein is attached.

Antennæ 6-jointed. Sixth joint with a short unguis. Joints III, IV, V, and VI with transverse secondary sensoria annular. Secondary sensoria rarely encircling the joints. Permanent sensoria at distal extremity of V and at base of spur on VI oval, fringed with cilia. Joint III with 6-13 sensoria, most frequently 10-11; IV with 2-4, most frequently 3; V with 2-4, most frequently 3; VI with 3-7, most frequently 5.

Relative length of joints I, 3.5; II, 3.5; III, 9.5; IV, 4.5; V, 5.5; VI, 9.25. The length of the antennal joints is quite variable even of the antenna of a single individual.

Relative length of fore femora 25; tibia, 29; tarsus, 7.5; middle femora, 20; tibia, 29; tarsus, 8; hind femora, 28; tibia, 39; tarsus, 10.

Coefficient of joint VI greater than antennal coefficient. More than 60 per cent of joints IV with less than 4 sensoria.

The Galls.—The galls are usually semi-globular. Not infrequently they are more or less cone-shaped. Normally located galls are situated at the base of the leaf, on its upper side. The color is green, or when exposed to the sun, tinged with reddish varied with yellow. The gall is composed of a much enlarged and thickened portion of the leaf blade. On the under side there is a somewhat curved mouth-like orifice bounded on one side by the much thickened midrib and on the other by a thickened fold in the leaf blade. A more or less broken portion of the blade usually extends along this fold nearly the entire length of the mouth.

Many times the blade of the leaf stands at an angle to the petiole. The opening in the gall is rarely equal to one-half the circumference of the gall and is not visible from above. The lip-like borders of the opening are frequently quite rough. Galls located at some distance from the base of the leaf and resembling those produced by *P. p.-venæ* sometimes occur, especially on heavily infested trees.

This aphid is frequently encountered in Utah, on balsam poplar, *Populus balsamifera*. It has been collected in this state from Big Cottonwood Canyon, Blacksmith Fork Canyon, Farmington, Hyde Park, Providence, and Salt Lake City. The material described was collected at Salt Lake City.

***Pemphigus populi-transversus* Riley.**

This aphid has, as its summer host, plants belonging to the family Cruciferae. Jones states that *Populus balsamifera*, *P. monilifera*, *P. trichocarpa* and *P. fremontii* have been men-

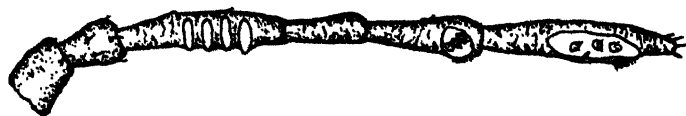


Fig. 5. *Pemphigus populi-transversus* Riley.
Antenna of spring migrant.

tioned as hosts. He also gives cabbage, turnip, mustard (*Brassica nigra*), cauliflower, broccoli, (*B. oleracea botrytis*), Brussels sprouts, rape, and several weeds belonging to the family cruciferae as hosts of the subterranean forms. While this aphid has been reported as damaging certain cruciferous crops in the south, no damage in the northern portions of its range has been reported.

In Utah this aphid was collected at Farmington, on June 28, 1923. At this time spring migrants and pupal nymphs were present in galls formed on the petiole near the leaf of cottonwood, *Populus deltoides*. Galls and stem-mothers apparently of this species, were collected at Santa Clara by Dr. H. J. Pack, during June, 1928.

***Pemphigus populi-venæ* Fitch.**

Pemphigus populi-venæ was described by Dr. Asa Fitch in 1859. Since the original description was published, this species does not appear to have been recognized but appears to have been confused by some aphidologists with *P. p.-caulis* and *P. p.-globuli*.

In his studies of this species Dr. Fitch appears to have failed to recognize the real nature of the aphids in the galls. It seems altogether probable that his male and female larvæ and pupæ were the early stages of the alate females (fundatrigenia).

The winged individuals were so briefly described by Fitch that the description is valueless for purposes of identification. Identifying aphids by the plant deformities produced is very apt to lead to confusion. Easily distinguished species produce very similar deformities and a single species may produce more than one form of deformity.

The Galls.—Dr. Fitch describes the galls of *P. p.-venæ* as “. . . . an oblong compressed excrescence like a cock's comb, of a light red color varied with pale yellow growing from the midrib of balsam poplar leaves on their upper side with an orifice on the opposite side. They are nearly semi-circular and half as high as long, being usually over a half inch in length, with uneven surface, their walls thick, brittle and succulent They are commonly placed near the base of the leaf but sometimes in its middle.”

Galls similar to those described by Fitch were collected by the senior author at Oak Park, Minnesota, on balsam poplar and near Spreckles, California, on *Populus trichocarpa*.

The aphids from these galls have some of the characters of *P. p.-caulis* and *P. p.-globuli* but are not wholly like either.

The most noticeable difference between *P. p.-venæ* and *P. p.-caulis* and *P. p.-globuli* is its smaller size. Dr. Fitch gives the length of *P. p.-caulis* as 2.54 mm. (0.10 inch), *P. p.-globuli*,

1.77 mm. (0.07 inch) and *P. p.-venæ*, 1.27 mm. (0.05 inch). The senior author has taken all three species on a single balsam poplar tree in Minnesota. The length of average-sized individuals in the collection is: *P. p.-caulis*, 1.84 mm.; *P. p.-globuli*, 1.79 mm.; and *P. p.-venæ*, 1.18 mm. *P. p.-caulis* from California measured 1.86 mm.; *P. p.-globuli*, 1.79 mm., and the aphids from the *P. p.-venæ* type of gall, 1.25 mm. Because of the similarity of the size of these species to those described by Dr. Fitch and the likeness of the galls of *P. p.-venæ* as described by Dr. Fitch to those collected in Minnesota and California, the aphid here described is considered the *P. p.-venæ* of Fitch.

DESCRIPTION.

Fundatrix:

Color.—Yellowish green.

Dimensions.—Total length about 1.91 mm.; width 1.34 mm.; relative length of antennal joints: I, 3; II, 2; III, 4.5; IV, 5. Joints III and IV faintly imbricated. Imbrications consist of slightly raised ridges bearing rows of very small spines on tubercles. A few rather large curved hairs on joints III and IV and at base of the weakly defined spur on IV fringed with cilia. Relative length of fore femora 13.5; tibia, 12; tarsus, 5.5; middle femora, 15; tibia, 17; tarsus, 6; hind femora, 19; tibia, 17; tarsus, 6.

Fundatrigenia (Summer migrant).

Color.—The color of the living insects is similar to that of other *Pemphigus* species producing galls on the cottonwood and balsam poplar. The light covering of whitish powder gives the insect a bluish tinge. The head and thorax are dark, almost black; coxæ, legs and antennæ brownish. Wing veins dusky; stigma dusky with a darker band along the posterior margin.

Dimensions.—Total length about 1.25 mm.; abdomen about 0.52 mm. wide; forewing 1.96 mm. long, 0.71 mm. wide; hind wing 1.47 mm. long, 0.46 mm. wide. Stigma 0.41 mm. long and 0.12 mm. wide where vein is attached. The wing venation is normal for the genus. The bases of the first and second discoidals of the forewing normally well separated, rarely arising from near the same point. The basal one-fourth to one-third of the third discoidal obsolete. Stigmal vein curved, well developed. Bases of diagonals of hind wing range from rather widely separated to arising from nearly the same point. The venation appears to be a mixture of that of *P. p.-caulis* and *P. p.-globuli*.

Relative length of fore femora 21; tibia 22; tarsus 7; middle femora 13; tibia 22; tarsus 7; hind femora 22; tibia 29; tarsus 9.

Antenna 6-jointed. Segment VI with a short unguis. Relative length of joint I, 3; II, 3; III, 8.5; IV, 4.5; V, 5.5; VI, 9. The length of the antennal joints is quite variable. In some individuals III is longer than VI, while VI is the longest in the majority of cases. Sensoria

on joints III, IV, and V, and VI annular; secondary sensoria rarely encircling the joints. Permanent sensoria at distal extremity of V and at base of spur on VI more or less oval, fringed with cilia. Joint III with 7-10 sensoria, most frequently 8-9; IV with 1-4, most frequently 3; V with 2-5, most frequently 3; VI with 3-7, most frequently 5.

Relative magnitude of antennal coefficient and coefficient of VI variable but most frequently the coefficient of VI slightly exceeds that of the antenna.

The Gall.—Dr. Fitch's description of the gall should be enlarged by stating that the galls vary in form from more or less oblong to semicircular and even almost triangular in outline. On heavily infested trees galls occur on both sides of the leaf. When on the underside they may be confused with those of *P. betæ*, being similar in form and location.

Aphids collected at Hyrum, Utah, on June 20, 1926, seem to be the species described by Fitch. These aphids were producing galls on the leaves of the narrow-leaved cottonwood, *Populus angustifolia*.

***Pemphigus populi-ramulorum* Riley.**

While this species was described from material collected on *Populus balsamifera* it occurs commonly on *Populus deltoides* in localities outside the range of the balsam poplar. This species resembles quite closely both *P. p.-caulis* and *P. p.-globuli*. The most distinctive character is the number of sensoria on joint V of the antennæ and the relative lengths of IV and V. Normally joint V has fewer sensoria than IV. Joint V is very often shorter than IV or equal to it in length. Less frequently V exceeds IV in length.

This aphid is frequently encountered in Utah and is particularly interesting because of the gall it produces on the young twig bark of poplars, especially *Populus balsamifera*. Collections made at Leeds, both from twig galls and from galls below the bases of the leaves on the petiole, indicate that this one species produces two types of galls. This is a rather uncommon occurrence among gall-forming aphids. The openings to the leaf galls are often slightly beaked, and the mouth does not always open along the same axis, which gives variation in appearance to the openings of different galls.

In Utah this species has been collected from Benjamin, Benson, Farmington, Holliday, Hooper, Leeds, Provo, St. George, Santa Clara, and Zion National Park.

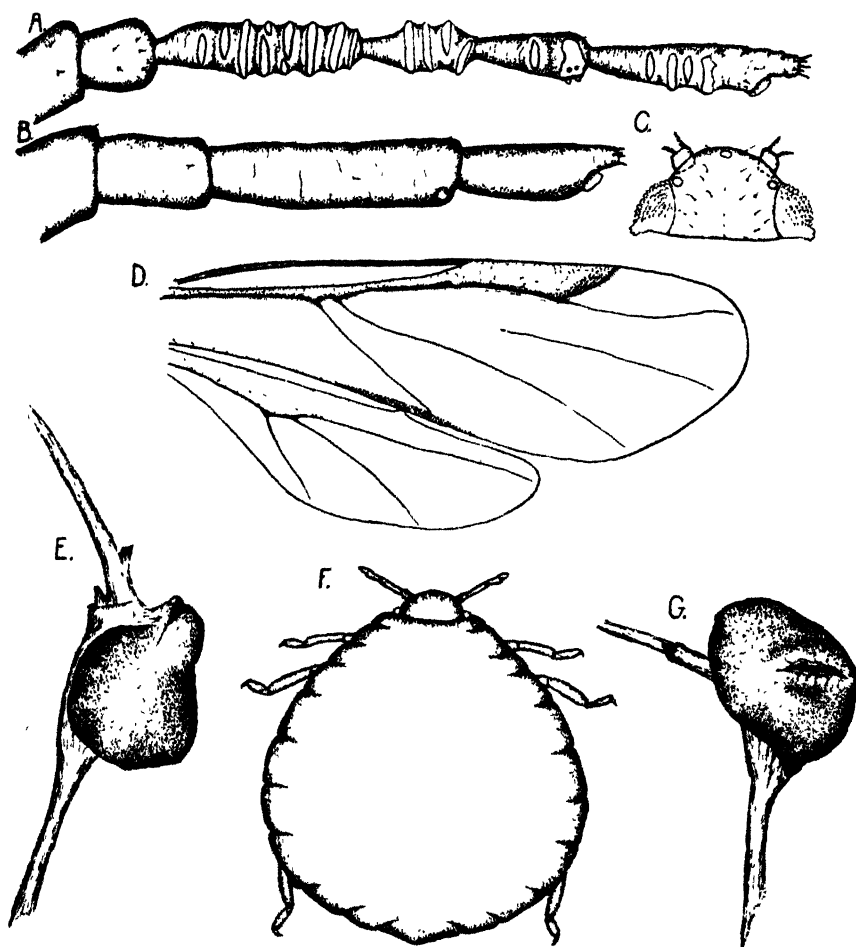


Fig. 6. *Pemphigus populi-ramulorum* Riley.

A, antenna of spring migrant; B, antenna of stem mother; C, head of spring migrant; D, wings of spring migrant; E and G, twig galls; F, stem mother.

***Pemphigus betæ* Doane. (*The Sugar-beet Root-Louse*)**

A pemphigid from beet roots grown at Pullman, Washington, was named "*Pemphigus betæ*" and described by Doane in 1900. In 1910 Williams described *Pemphigus balsamiferae*. This aphid was taken at Squaw Creek, Nebraska, on *Populus balsamifera*. In 1914 the senior author discovered that the sugar-beet root-louse in Colorado is the summer and fall genera-

tions of *P. balsamiferae* from the narrow-leaved cottonwood, *Populus angustifolia*. Unless the beet is the host of two Pemphigus species and the one in Washington is different from the one feeding on beets in Colorado, *P. balsamiferae* Williams, becomes a synonym of *P. betæ* Doane. In this discussion *P. balsamiferae* is considered the spring form of *P. betæ*.

P. betæ occurs on the balsam poplar within the western range of this tree and on *Populus angustifolia* where this tree occurs naturally. Its galls are located on the underside of the leaf. They may easily be confused with the galls of *P. p.-venæ*. The aphids are easily separated, however, since *P. betæ* (*balsamiferae*) has no secondary sensoria on joint VI of the antennæ.

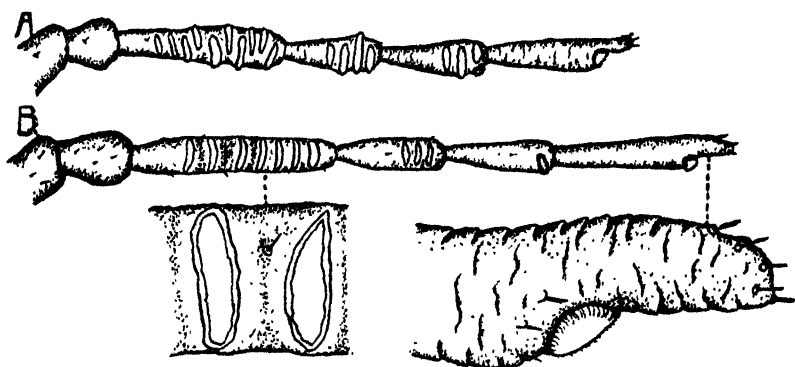


Fig. 7. *Pemphigus betæ* Doane.

A, antenna of spring migrant; B, antenna of fall migrant.

Very rarely there may be one or two very small secondary sensoria on VI. These are not noticeably raised above the surface of the joint and are never equal to the diameter of the joint in length.

The following unpublished chapter in the life history of *P. betæ* was worked out by the senior author in 1921.

Hibernating aphids were collected from the soil November 2d. These were confined in salve boxes in a greenhouse under ordinary greenhouse temperatures. The aphids collected November 2d. are designated the first generation. The second generation (young of the hibernating lice) appeared December 31st after nearly 2 months' inactivity on the part of the hibernating individuals. The third generation appeared January 21st; the fourth generation, February 24th; the 5th, March 12th; the 6th, March 24th; the 7th, April 8th, and the 8th, April 29th.

The age of the various generations when reproduction began was: second generation, 21 days old; third, 34 days; fourth, 16 days; fifth, 12 days; sixth, 15 days; and seventh, 21 days. The variation in ages is probably due to variations in temperature and the condition of the food supply. Low temperatures retard development and high temperatures quicken it.

The first, second, third, fourth, and fifth generations were all apterous viviparous females which began reproducing immediately upon becoming mature. The first alate forms (sexuparæ) appeared in the sixth generation. The sixth and seventh generations were composed of about equal numbers of apterous viviparous females and alate sexuparæ. The apterous females of the sixth and seventh generation began to reproduce as soon as mature. The offspring of the sixth generation were of four kinds. Those of the apterous forms were apterous viviparous females and sexuparæ; those of the sexuparæ, true males and females. The offspring of the seventh generation (the eighth generation) were of four kinds also. Those of the apterous viviparous females were apterous forms and sexuparæ. The former ceased feeding and became inactive upon reaching mature size. They sought out crevices in the soil where they became completely covered with the wax secreted by their wax glands. Those of the sexuparæ were true males and females. The hibernating forms of the eighth generation differ from the apterous forms of the sixth and seventh generations, since upon reaching sexual maturity they produce only apterous forms.

This change into hibernating forms appears to be biological function and not a temperature reaction.

Control.---Rotation does not reduce sugar-beet root louse infestation. In fact, beets following beets are usually less heavily infested than beets following alfalfa or small grain. In the latitude of Denver, Colorado, migration from the cottonwood to the summer host takes place during the last two weeks of June. Parker has shown that near Billings, Montana, soil moisture is a determining factor in beet root-louse development and infestation. Heavy rains during this period have the same effect.

This aphid is frequently encountered in the beet fields throughout Utah. At times it is present in damaging numbers,

causing the beets to be unthrifty. In extreme cases, the beets become shrunk and flexible, and the tops become yellowed.

Badly infested beet roots are easily pulled, and have a grayish, mouldy appearance. This grayish substance is a secretion from the wax pores of the bodies of the aphids. The yellowish wingless aphids (and during late summer and fall some darker winged forms) are found under this flocculent material. The winged aphids are frequently abundant in the beet fields of Utah during September and less numerous during August and October. During the fall this aphid occasionally becomes abundant on narrow-leaved poplars. The aphids migrate from the beet fields to this tree, and here the overwintering eggs are laid. During the next spring the eggs hatch, and the nymphs develop into the broad abdomened stem-mothers. These wingless females produce the galls on the leaves on which they feed, and in this gall the second generation develops and acquires wings, before returning to the beet fields.

Hibernating aphids have been encountered several times at Lewiston and Amalga, Utah, in early spring, following a year of heavy infestation.

The aphid several times has invaded the experimental greenhouses at Logan, when beets were being grown. In one instance, when a high humidity had been maintained for several weeks, the aphids established on the petioles and leaf-blades of the sugar-beets, many aerial colonies which were almost entirely covered by the grayish waxy secretions.

This aphid has been collected in Utah from the following localities: Amalga, Benson, Brigham, Collinston, Cornish, Delta, Garland, Hoytsville, Hyde Park, Lehi, Lewiston, Logan, Madison, Millville, Richfield, Richmond, Salt Lake City, Smithfield, and Trenton.

***Prociphilus fraxinifolii* (Riley).**

Prociphilus fraxinifolii differs from typical *Prociphilus* species in the nature of the individuals composing the various generations. The following observation was made by the senior author at Longmont, Colorado, in 1925.

A young white ash tree in one of the city parks was very heavily infested with *Proc. fraxinifolii* on June 18. At this time many first instar lice were travelling from the infested tips

of the branches toward the trunk of the tree. Upon reaching the trunk, these young lice travelled up or down until another branch was reached, when they started toward its tip. It was thought that the migrating lice might be in search of fresh leaves upon which to locate.

At the time of observation some curled leaves contained stem mothers and many large mature apterous females which were giving birth to the young already mentioned. Others contained only a limited number of these young.

A cluster of curled leaves containing the stem mothers and apterous females was removed and fastened to a branch of a young ash tree that had no curled leaves. Immediately the young were observed travelling toward the trunk of the tree. The second day after the curled leaves were placed on the young tree, the leaves of nearly every branch below the point where the curled leaves were attached were badly curled.



Fig 8. *Prociphilus fraxinifolii* (Riley)
Antenna of spring migrant.

On the fourth day no leaves above the point where the curled leaves were attached to the branch were curled. The migration of young, therefore, appears to be mainly downward. The third and fourth day after the curled leaves were placed on the young tree they were completely dry and the mature lice in them were dead. Apparently the stem mothers and second generation apterous females do not migrate.

This observation indicates that the sequence of generations of *Proc. fraxinifolii* is somewhat similar to that of *Eriosoma* species. No winged individuals were secured. It is believed that the winged lice are produced by the migrating generation (the young of the second generation), and, therefore, belong to the fourth generation.

Fall migrants, collected October 23, 1908, were examined by the senior author through the courtesy of J. J. Davis. They are very similar to the alate forms produced on the ash. The principal difference is in the number of sensoria on the antennal joints. The summer migrants have about 8 sensoria on III, 5 on IV, 6 on V, and 4 on VI. The sexuparae have 2 to 3 on III, 2 to 3 on IV, 2 or 3 on V, and 1 or 2 on VI.

THE ASILIDÆ OF CUBA (DIPTERA).

S. W. BROMLEY.

INTRODUCTION.

The present paper is the outcome of a study of the Asilid fauna of Cuba, begun in 1926, during the writer's visit to this beautiful and interesting island.

The collecting done by the writer was confined to the western part of the island, principally in Habana province in the characteristic red clay ("tierra colorada") country. Most of this region has been under cultivation or grazing for several hundred years and many of its natural features have been lost. The Royal Palm characterizes this region, in some places forming almost pure stands.

Asilidæ do not appear in numbers in this region until about the middle of April. During May and June, they form a very conspicuous and characteristic feature of the Dipterous fauna. As the writer left before the first of May, the best collecting was missed, but through the kindness of Mr. S. C. Bruner, Entomologist at the Estación Experimental Agronómica, Santiago de las Vegas, the loan of the Station collection of Asilidæ was obtained which, together with a collection purchased from Sr. Fermin Cervéra, of Habana, formed a nucleus for the study of the Asilidæ of this region. The Station collection contained many interesting forms, many of which were collected by Sr. Julián Acuña in Camaguey Province.

Mr. Nathan Banks of the Museum of Comparative Zoology, Cambridge, Mass., kindly loaned me material from the Loew Collection, as well as other material in the Museum of Comparative Zoology collected by Messrs. Salt and Barbour. Additional specimens were loaned by Dr. Ramsden of Guantánamo, Cuba and by Mr. C. W. Johnson of the Boston Society of Natural History, while Dr. J. Bequaert kindly presented me the specimens collected by him in Cuba in 1926.

To all these workers, the writer wishes to express his thanks and appreciation. To the staff of the American Museum of Natural History the writer is particularly grateful for the use of the library and other timely assistance.

While in Habana, the writer had the opportunity of examining the famous Gundlach collection. The family Asilidæ is well represented in this collection, which is at the present time housed in the Instituto de Segunda Enseñanza de La Habana at Zulueta and San José Streets. The collection is contained in small glass-topped boxes which have been sealed, so that only superficial observation through the glass may be made. The specimens are well mounted and in excellent condition.

In the course of collecting, many specimens were taken with prey, by Mr. Bruner. Some mention is made of the species taken by various robber flies in the present paper, but detailed data is being saved for another publication.

Unless otherwise stated, the types of the new species described are in my own collection.

Key to the Subfamilies.

- A. Marginal cell open.
 - B. Palpi one-jointed; small, slender species; antennæ with slender terminal arista LEPTOGASTRINÆ
 - BB. Palpi two-jointed; antennæ with or without a thickened terminal style DASYPOGONINÆ
- AA. Marginal cell closed.
 - C. Antennæ with or without a terminal style, never a terminal arista; palpi two-jointed LAPHRIINÆ
 - CC. Antennæ with slender terminal arista; palpi one-jointed, ASILINÆ

LEPTOGASTRINÆ.

Leptogaster Meigen

Typical Species: *L. cylindricus* DeG.;—Europe.

Key to the Species.

- 1. Hind tibia long and slender; dark brown *obscuripes* Loew
- Hind tibia shorter and stouter; distinctly banded 2
- 2. Hind tibia light yellow with a median and an apical black band, *venustus* new species
- Hind tibia dark brown with broad light-reddish brown median band, *cubensis* Bigot

Leptogaster obscuripes Loew.

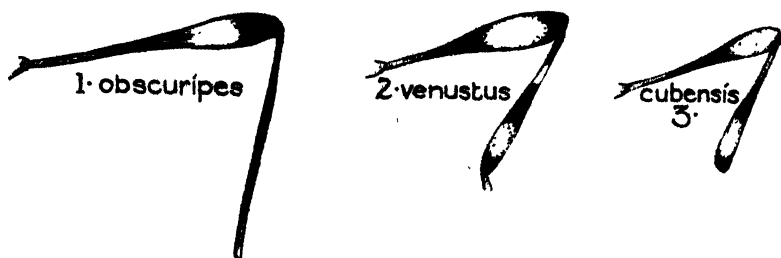
(Plate I, Fig. 16).

Leptogaster obscuripes Loew. Berlin, Ent. Zeitschr. VI, 191, 13, (1862); Aldrich, Cat. N. A. Dipt. 254 (1905); Kertész, Cat. Dipt. IV, 55, (1909).

Leptogaster ramoni Jaenke, Abhandl. Senckenberg. Naturf. Ges., VI, 354, 56, (1867).

Total length 10–15.5 mm. A dark-colored, slender, elongate species with the hind tibia long and slender and nearly uniformly dark brown, only the base and extreme tip being slightly lighter than the rest of the tibia. Text Fig. 1.

First two segments of antennæ reddish, 3rd and arista black. Mystax sparse, white. Proboscis dark brown. Face silvery pruinose. Palpi brown. Thoracic dorsum reddish brown with a median black stripe and two dark lateral lines separated from the median stripe by two white pruinose streaks, one on each side. Pleura silvery pruinose. Wings hyaline, iridescent. Halteres pale brown. Scutellum dark brown. Legs brownish, the anterior pair lightest and nearly uniformly colored. The middle pair darker, the femur and tibia with the apex lighter. The hind pair very long, dark brown; a light band at the distal portion of the femur which is slightly swollen; the extreme tip of the tibia and tarsus lighter, but with the distal tips of the tarsal segments nearly black. Abdomen long, slender, dark brown, the incisures very slightly lighter. The distal portion of the 8th segment and genitalia in the male are enlarged.



POSTERIOR FEMUR AND TIBIA IN LEPTOGASTER.

Fig. 1, *Leptogaster obscuripes* Loew. Fig. 2, *L. venustus* n. sp.
Fig. 3, *L. cubensis* Bigot.

Jaimanita, Habana, VIII, 1912 (Cervéra). Banes, March 21, 1926 (Bequaert). Soledad, 8-11, '25 and 26-V, '25 (Salt). Other specimens, unlabeled, probably from vicinity of Habana (Cervéra). One specimen with the detached head of a small ant clinging to the hind tarsus.

Leptogaster cubensis Bigot.

Gonypes cubensis Bigot. Sagra's Hist. de La Isla de Cuba, p. 2, VIII, 332, (1856).

Length 9 mm. A small slender, grayish species with leg markings as in Fig. 3.

One specimen, a female, Habana, June 5, 1922. Coll. S. C. Bruner.

Leptogaster venustus new species.

Length 7-11 mm. Leg markings as in Fig. 2.

Male. Face, vertex, and occiput grayish pollinose. Antennæ (3rd segment black), palpi, and proboscis brownish. Mystax composed of 3 or 4 fine white bristles. Thorax brownish-gray, pleura white

pollinose. Two black bristles on mesonotum above each wing. Disc of mesonotum with three brownish lines. Scutellum grayish pollinose. Wings hyaline. Halteres pale yellow, knobs light brown. Legs yellowish with yellowish bristles. All femora and tibiæ brownish at tip. Front tibiæ, middle femora and tibiæ with brown mark on median anterior aspect. In all tarsi the first segment is very pale yellow; the other segments darker. Hind tibia banded as follows: basally light yellowish-brown; followed by a white band; then the median dark brown band, then a yellowish-brown band and finally the apical brown band. Abdomen grayish brown, the segments with pale posterior margins. Genitalia rather large; the forceps hooked, curved in at tips.

Female. Similar. The abdomen is more clavate; the 1st 4 segments narrow, the 5th widening, the 6th and 7th of equal width.

Holotype, male. Cuba, Gundlach (Loew Collection) 128-258 in M. C. Z. Allotype, female, Camaguey, Cuba. (J. Acuña, Coll.), Aug. 20, 1924. Paratypes ♂♂, Camaguey, Cuba, (J. Acuña Coll.), Aug. 20, 1924. Soledad, Cuba, May 4, 1925, (Geo. Salt). ♀♀, Camaguey, Cuba (J. Acuña Coll.), Aug. 20, 1924; Soledad, Cuba, June 20, 1925, (Geo. Salt).

This species bore Loew's manuscript name *venustus* which I have adopted.

Leptogaster clavipes Johnson (Ent. News VIII, 120. 1897) described as *longipes* (præoc.) Acad. Nat. Sci. Phil. 273. 1894 from Jamaica has not as yet been recorded from Cuba.

DASYPOGONINÆ.

Key to the Genera.

- A. Front tibia without a terminal claw-like spur.
 - B. Eyes closely approximate at top of head; elongate slender species *Plesiomma*
 - BB. Eyes well separated at top of head; stouter species; front and middle femora with a patch of short, stout bristles below *Sphægus*
- AA. Front tibia with a terminal claw-like spur.
 - C. Posterior pulvilli much shorter than the elongate claws; scutellum without bristles *Blepharepium*
 - CC. Posterior pulvilli not much shorter than the claws; scutellum with bristles. *Deromyia*

Plesiomma Macquart.

Typical Species: *P. testacea* Macquart—S. America.

Key to the Species.

- 1. Large black species *funneum* Loew
- Yellowish brown species 2
- 2. Wings brownish or smoky with pale yellowish areas in middle 3
- Wings uniformly hyaline or smoky 4

3. Dorsum of thorax with three distinct black stripes, the middle one nearly uniform in width, 11-16 mm *lineatum* Fabricius
 Thorax less distinctly marked with brown, the median stripe broadening anteriorly, 18-25 mm *indecorum* Loew
4. Wings slightly darker toward costa; anterior branch of 3rd vein without a stump vein *leptogaster* Loew
 Wings uniformly smoky; anterior branch of 3rd vein with a stump vein *salti* new species

All of the Cuban species examined by the writer have the mystax composed of only one row of bristles. The Mexican species have more than one row of bristles in the mystax.

***Plesiomma funestum* Loew.**

Plesiomma funesta Loew, Wien. Entom. Monatschr. V, 35, 6, (1861).

Plesiomma funestum Kertész, Catal. Dipt. IV, 145, (1909).

Dioctria lugubre Jaennecke, Abhandl. Senckenberg. Naturforsch. Ges. VI, 356, 59, (1867).

Length 28-30 mm. A large beautiful species, deep black. The wings are black with a blue-green lustre. The first two pairs of legs or in some cases only the anterior pair are reddish-yellow.

Three males, Sierra Rangel, Pinà del Río, Cuba, Aug. 29, '27. Elevation 1,500 ft. Collected by J. Acuña and S. C. Bruner.

This species, the largest of the genus in Cuba, is undoubtedly memetic of the tarantula hawk, *Pepsis ruficornis* LeP.

***Plesiomma lineatum* Fabricius.**

Asilus lineatus Fabricius, Species Insect. II, 465, 28, (1781).

Dasypogon lineatus Fabricius, Systema Antliat. 167, 13, (1805).

P. macra Loew, Wien. Ent. Monatschr. V, 25, 5, (1861).

Two males of this species are at hand, one from La Milpa, Cuba, (Cienfuegos) July 4, 1925, (Geo. Salt) and San José, Matanzas, Cuba, Aug. 16, 1927, collected by J. Acuña.

***Plesiomma indecorum* Loew.**

(Plate I, Fig. 12).

Plesiomma indecora Loew, Berlin. Ent. Zeitschr. X, 19, 33, (1866).

Plesiomma longivenire Schiner, Verh. Zool. Bot. Ges. Wein. XVII, 375, 38, (1867).

Length: 19-26 mm. A large yellowish brown species, evidently the most common Cuban representative of the genus. A very pale specimen in the Loew collection bears the manuscript name "hypoxantha" but I do not think it is sufficiently distinct to be considered as a different species.

Specimens at hand from Habana Province; Vicinity of Habana, (T. Barbour); Santiago de Las Vegas, May 29, 1926;

June 16, 1926; July 15, 1926 (S. C. Bruner) Camaguey, July 5, 1925 (J. Acuña); Soledad June 2, 1925 (Geo. Salt).

***Plesiomma salti* new species.**

Length 17 mm. A yellowish-brown species with black thoracic lines, related to *P. leptogaster* Loew, but differing in having the head proportionately narrower, and the wings uniformly smoky in color, the anterior branch of the 3rd vein with an appendix.

Male. Head yellowish-brown, eyes black. Third joint of antennæ darker above, style black. Mystax composed of 6 bristles, pale yellowish brown. Antennal bristles of same color. Beard and palpal hairs pale yellow. Thorax yellowish-brown. Pleura with two black stripes, the first extending from behind the spiracle to the first coxa; the second from the base of the wings to the second coxa; and a black spot in front of the hind coxa. The pronotum has 2 dark brown spots above, and the mesonotum bears three black lines, the median line broadening very slightly anteriorly. The bristles of the mesonotum are dark brown anteriorly, those of the posterior portion, black. The parascutellum bears yellow bristles. The scutellum is dark brown, and bears two long marginal bristles. The legs are reddish yellow with concolorous bristles. The tips of the femora are darker as are the tips of the posterior tibiæ. The posterior femora bear a light brownish preapical ring. Wings uniformly smoky, the veins brown. Halteres yellowish. Abdomen yellowish-brown, becoming darker apically. The anterior margin of the 1st segment bears a blackish line. The second segment has a median dark area and the third segment is darker anteriorly. Genitalia small, dark yellowish brown with concolorous hairs and a few black hairs anteriorly. The hairs of the preceding segment are blackish.

Holotype, male, Soledad, Cuba, June 20, 1925, Geo. Salt in M. C. Z.

***Sphageus* Loew.**

Typical Species: *S. chalcoproctus* Loew—Cuba.

This genus is related to *Dizonias*, from which it is distinguished by the lack of the excision on the 3rd segment of the antenna, and the undersides of the front and middle femora have a patch of stout bristles. The mystax extends nearly to the antennæ.

***Sphageus chalcoproctus* Loew.**

Sphageus chalcoproctus Loew, Berlin Entom. Zeitschr. X, 31, 55, (1866).

Length 22 mm. A large reddish-yellow species with pile and bristles of head, thorax and abdomen, golden. The legs are reddish yellow with patches of black bristles on the underside of the front and middle femora. The thorax is black with a golden pruinosity over a considerable part of its area and the scutellum and the abdomen are

yellowish-red. The posterior margins of the abdominal segments are narrowly black. There is a whitish spot on each side of the anterior portion of segments 2-4.

A male, VII, 1922, Playa Chevo, Habana, (F. Cervéra).

***Deromyia* Phillippi.**

Typical Species: *D. gracilis* Phillippi—Chile.

Key to the Species.

1. Three velvety black stripes on mesonotum..... *ternata* Loew
Two median black stripes closely approximated..... *bilineata* Loew

***Deromyia bilineata* Loew.**

Deromyia bilineata Loew, Berlin. Ent. Zeitschr. X, 23, 40, (1866).

A study of the type specimen failed to reveal any striking difference from *discolor* Loew. This species has not since, to my knowledge, been taken in Cuba. The species described by Back (Trans. Amer. Ent. Soc. vol. XXXV, p. 356, 1909) from Florida as *bilineata* is a new species and quite distinct from the type of Loew's *bilineata*. Back's original observation (p. 357) that *bilineata* is a synonym of *discolor* is, probably, correct. but I should like further material before stating definitely.

***Deromyia ternata* Loew.**

(Plate I, Fig. 20).

Deromyia ternata Loew, Berlin Ent. Zeitschr. X, 22, 58, (1866).

Length, 19-22 mm. This is a common species in Cuba. It differs from the species generally known as *ternata* in U. S. which is a new species. The true *ternata* has the median black line on the mesonotum extending to the anterior margin and does not become reddish anteriorly as in the U. S. species. The thorax is also covered with a more intense golden pollinosity and there is a dark area on the pleura above the last two coxæ, which is missing in the U. S. species. The Cuban species is also more robust, the legs stouter and the bristles stronger.

Specimens at hand from Habana province, collected by S. C. Bruner, May, June. There is also a female from Sto. Tomás, P. de Zapata, Cuba May 5-9, 1927 collection by S. C. Bruner and J. Acuña.

***Blepharepium* Rondani.**

Typical Species: *B. lurida* Rondani. "*Patria ignota*".

Blepharepium contains several South and Central American species which have generally been considered synonymous.

The genus itself has been confused with *Senobasis* to which it is entirely unrelated, its nearest affinities being with *Deromyia*. The following key points out characteristic differences between the species.

1. Posterior femora black basally; reddish or yellowish apically 2
Posterior femora uniformly colored 3
2. Thoracic markings black *annulatum* Bigot (Cuba)
Thoracic markings reddish *secabilis* Walker (Mexico)
3. Mostly black; proboscis black, posterior femora black or dark brown,
cayennensis Fabr. (Guiana)
Mostly reddish yellow; proboscis reddish; posterior femora dark reddish-
yellow *coarctata* Perty (Brazil)

***Blepharepium annulatum* Bigot.**

(Plate I, Fig. 21).

Senobasis annulata Bigot, Sagra's Hist. de la Isla de Cuba, p. 2, VII, 331, (1856).

Length 21–24 mm. A large yellowish species banded with black, apparently mimetic of the common large *polistes* wasps *P. major* or *cubensis*.

Specimens at hand from Habana Province collected by S. C. Bruner and from Guantanamo, collected by Dr. Ramsden. One specimen taken feeding on a worker honey-bee.

LAPHRIINÆ.

Key to the Genera

- A. Veins at outer ends of discal and 4th posterior cells parallel or nearly continuous in the same straight line.
B. First antennal joint much more than twice the length of the second *Cerotainia*
- BB. First antennal joint not more than twice as long as second *Atomosia*
- AA. Veins at outer ends of discal and 4th posterior cells not parallel but forming an angle.
B. Proboscis long, straight, slender, of uniform width; abdomen coarctate; antenna longer than length of thorax *Rhopalogaster*
- BB. Proboscis short, stout at base, pointed or upturned at tip; stout, hair species *Andrenosoma*

***Cerotainia* Schiner.**

Typical Species: *C. xanthoptera* Wied. "Patria ignota".

One species only is represented in the present collection.

***Cerotainia laticeps* new species.**

(Plate I, Fig. 2).

Total length, 5 mm. A small black species, proportionally shorter and broader and with a wider head than *C. macrocera*. Dorsum of thorax with very fine appressed, bronze pubescence. Antennæ and proboscis black. Mystax scanty, white. Frons silvery pruinose.

Thorax black with very fine bronze pubescence. A patch of long white hairs in front of halteres. Femora and tarsi black; tibiae brown except tips which are black. Legs with fine white hairs. Wings nearly hyaline with iridescent reflections. Halteres reddish. Abdomen short and broad; black with inconspicuous metallic reflections.

Holotype (♂) Sto. Tomás, P. de Zapata, Cuba, May 5-9, 1927. Collectors (S. C. Bruner and J. Acuña). Allotype, ♀, Cuba (Priehl) Loew collection, Mus. Comp. Zool. Paratypes, Herra Dura, Cuba, collected by Metz and received from C. W. Johnson. Soledad, Cuba, June 8, 1925 (Geo. Salt). Sto. Tomás, P. de Zapata, Cuba, May 5-9, 1927 (S. C. Bruner and J. Acuña); Camaguey, Aug. 20, 1924 (J. Acuña) (feeding on a small winged ant) and a damaged specimen from the Loew collection marked 3/130.

The Priehl specimen (Loew collection) bears the manuscript name *laticeps* which I have adopted for the species.

Atomosia Macquart.

Typical Species: *A. puella* Wied.—N. America.

Key to the Species.

1. Ground color of body metallic blue..... *metallica* new species
Ground color of body otherwise..... 2
2. Hind femur mostly black..... 3
Hind femur mostly yellowish or reddish..... 5
3. Front femur reddish..... *maestra* new species
Front femur black..... 4
4. Mystax white..... *incisularis* Macquart
Mystax grayish or black..... *parva* Bigot
5. Dorsum of thorax silvery pubescent and pruinose; stout species,
pubescens new species
Dorsum of thorax otherwise..... 6
6. Legs mostly yellowish; thoracic dorsum light brassy pruinose..... *similis* Bigot
Legs nearly uniformly reddish; small species..... *erverai* new species

Atomosia incisularis Macquart.

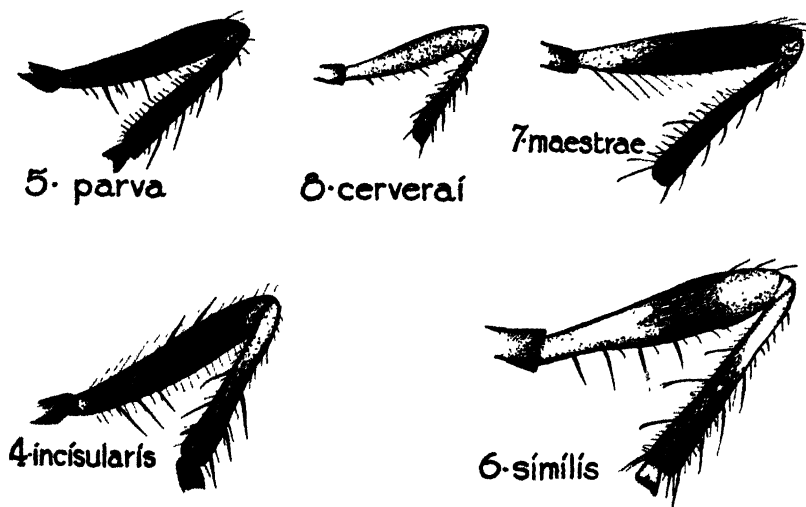
Atomosia incisularis Macquart, Dipteres Exotiques I, 2, 76, 4, (1838).

A small (7 mm.) black species related to *A. puella* Wied. The mystax, beard, face and front is white, the legs black and fuscous as represented in Fig. 4. The first posterior cell is usually open although narrowed at the margin, but in one specimen this cell is closed. There are some white bristles on the posterior tibiae.

Several specimens from the Loew Collection one bearing the date Habana, Dohrn, others bearing the label "Poey." One specimen has the 1st posterior cell closed at the margin and bears Loew's MS name "clausa."

A specimen from Santiago de Las Vegas, May 19, 1916; another from Soledad, June 20, 1925 (Geo. Salt).

This species and the following seem to be very closely related and a large series of specimens may prove the next to be simply a variety of *incisularis*.



POSTERIOR FEMUR AND TIBIA IN *ATOMOSIA*.

Fig. 4, *Atomosia incisularis* Macq. Fig. 5, *A. parva* Bigot. Fig. 6, *A. similis* Bigot.
Fig. 7, *A. maestrae* n. sp. Fig. 8, *A. cerverai* n. sp.

Atomosia parva Bigot.

(Plate I, Fig. 8).

Dasypogon parvus Bigot, Sagra, Hist. de La Isla de Cuba, p. 2, VII, 330, (1856).

A small black species, averaging slightly smaller than *incisularis*, from which it may be distinguished by the grayish or blackish mystax, the narrower white or grayish incisures of the abdomen (usually only apparent on the posterior borders of the 4th and 5th segments), and the more uniformly piceous legs with all black bristles on the posterior tibiae. Fig. 5.

Eleven specimens from Santiago de Las Vegas, April 20–June 11. Two from Jarahueca July 14–18, 1927, (S. C. Bruner).

Atomosia pubescens new species.

(Plate I, Fig. 3).

Total length 5.5–7.5 mm. A robust black species with broad abdomen, broadly rounded at the tip. Thoracic dorsum with thickly-set appressed white pubescence. Antennæ, proboscis, frons and palpi black. Mystax, beard, occipital and palpal hairs silvery white. Coxal

and pleural hairs also white. Scutellum with short, thick, silvery white pubescence and about 6 or 7 fine white upturned bristles along margin. Legs dull reddish with fine white hairs and bristles. The tarsi and apices of the tibiae are brownish and there are brownish cloudings on the dorsal side of the femora becoming darker toward the apices. Wings hyaline; the first posterior cell closed at the margin of the wing. Abdomen black, punctulate, covered with very short, scattered, white pubescence. Posterior margins of each segment, except the first very narrowly white.

Holotype, ♂, Soledad Cuba, June 2, 1925 (Geo. Salt) in M. C. Z; 9 paratypes Soledad June 2-June 25, 1925 (Geo. Salt).

***Atomosia maestræ* new species.**

Total length 8-9 mm. Slender black species with slightly fumose wings. First two segments of antennae reddish brown; 3rd missing. Frons with silvery pubescence and bloom. Mystax thin, white; occiput with inconspicuous white bloom. Pleura whitish pruinose and apices of femorae and of meso-tibiae darker. Hind legs nearly black with the exception of the coxae and bases of the femora which are yellowish (Fig. 7). Wings light grayish with iridescent reflections. Abdomen dull black, slightly constricted at juncture of 2nd and 3rd segments. Incisures narrowly white.

Holotype, ♂, Sierra Maestra, Cuba, July 10-20, 1922. (S. C. Bruner and C. Ballou) Alt. 3000-3500 ft. Allotype, ♀, Pico Turquino, Cuba July 20, 1922 (S. C. Bruner and C. Ballou).

***Atomosia cerverei* new species.**

Total length 4 mm. A very small black species with reddish brown legs and black antennae. Frons whitish pruinose, mystax thin, white. Occiput with inconspicuous whitish bloom. Thorax black, nearly bare. Pleura with inconspicuous whitish bloom. Wings hyaline with iridescent reflections. 1st posterior cell open. Halteres reddish. Legs reddish brown, the posterior tibiae and tarsi darker (Fig. 8). Abdomen shining black, incisures white, rather short and broadened toward tip, slightly constricted at junction of 2nd and 3rd segments.

Holotype, ♂, Soledad, May 27, 1925, (Geo. Salt) in M. C. Z. Named in honor of Sr. Fermin Cervera, the well-known collector and naturalist, late of Habana, Cuba.

***Atomosia similis* Bigot.**

Plate I, Fig. 15

Atomosia similis Bigot, Sagra, Hist. de La Isla de Cuba, p. 2, VII, 332 (1856)

A black species (8-11 mm. in length), covered sparsely with fine, short whitish pubescence giving it a silvery gray appearance. The legs

are yellow with brown markings. (Fig. 6.) The first segment of the antenna is yellowish, the second and third brown. The mystax, beard, palpal hairs and fine hairs of the head are white. The bristles of the throat are yellowish. Most of the hairs and bristles of the legs are white. Wings hyaline, veins at the base yellowish.

Specimens at hand from Santiago de Las Vegas collected by Mr. S. C. Bruner and Mr. B. T. Barreto, June 2-26; Guantanamo collected by Dr. C. T. Ramsden July 25, 1915; Candelaria May 10, 1924 collected by C. H. Ballou; Sto. Tomás, P. de Zapota, May 5-9, 1927 (Bruner et Acuña).

***Atomosia metallica* new species.**

Total length 5 mm. A slender, nearly bare, dark metallic blue species. Vestiture of head scanty, white. Frons silvery pruinose; occiput with whitish bloom and hairs. Thorax with a few scattered white hairs and a few black bristles posteriorly. An inconspicuous whitish bloom on the pleura and 3 long black bristles in front of the halteres. Legs yellowish with scattered dark hairs. Posterior femur with brownish pre-apical band. Apex, white. Posterior tibiae and all tarsi brownish. Scutellum bare with two long black bristles on posterior apex. Wings hyaline with iridescent reflections. First posterior cell open. R_1 makes inward bulge near the margin of the wing where R_2 meets it, closing the marginal cell. Halteres light yellowish. Abdomen slender, nearly black with bluish reflections, gradually widening towards the tip. Finely punctulate with fine white inconspicuous pubescence. The incisures very narrowly white.

Holotype, ♂, Palma Mocha, Sierra Maestra, Cuba, July 10-20, 1922 (C. H. Ballou and S. C. Bruner); 4 paratopotypes same data.

***Rhopalogaster* Macquart.**

Typical Species: *R. longicornis* Wied.—Brazil.

A single specimen in the collection, which was found to be a new species, is here described.

***Rhopalogaster bella* new species.**

(Plate I, Fig. 5).

Female. Total length 11 mm., excluding antennæ which are 4 mm. in length. Rather slender, black species with petiolate abdomen. Antennæ long, black; the first segment about 1/3 the total length; second segment very small; third segment long and blade-like. Vestiture of head, including beard, mystax, pubescence of frons, etc., white. Occiput whitish pruinose. Palpi very small, proboscis long (about 1.75 mm. in length) slender. Thorax and legs black with whitish hairs. Pleura whitish pruinose. Mesonotum whitish pruinose with a median black

line and two broad lateral spots. Scutellum black with margin thickly set with fine white upturned bristles. Wings hyaline at base, slightly brownish beyond middle. 1st posterior cell closed. Legs black with fine, long, white hairs. Abdomen metallic blue with brownish incisures. Hairs of abdomen fine, white. 2nd segment long, slender and of uniform width, 3rd segment broadened posteriorly; 4th and 5th broad; 6th tapering to apex.

Holotype, ♀, Camaguey, Cuba, Aug. 20, 1924. (J. Acuña Coll.).

***Andrenosoma* Rondani.**

Typical Species: *A. ater* (L.)—Europe.

Key to the Species.

1. Abdomen red or orange with exception of anterior and lateral margins of 1st segment which are black *acunai* new species
At least half of abdomen black 2
2. Dorsum of 1st two abdominal segments with fine appressed white pile (ground color dark red) *quadrimaculata* new species
Abdomen otherwise 3
3. Scutellum reddish; large species (23 mm.) *varipes* Banks
Scutellum black or metallic blue 4
4. Scutellum metallic blue *chalybea* Williston
Scutellum black *crassa* new species

***Andrenosoma chalybea* Williston.**

(Plate I, Fig. 17).

Andrenosoma chalybea Williston. Trans. Am. Ent. Soc. XII, 56. 1885.

Blackish species with metallic blue abdomen, scutellum and legs. Mystax mostly black, a few white hairs at sides or intermingled; beard white. 12–20 mm.

Male, Taco Taco, Cuba. April 1–6, 1922 (S. C. Bruner, J. Acuña, C. H. Ballou, coll.). A large male from the Loew collection (²²⁰/₄₂₈) bears the manuscript name "panthophora".

***Andrenosoma varipes* Banks.**

Laphria varipes Banks. Canadian Entomologist 52. 67. 1920.

A large robust grayish species with dull black abdomen, the last three segments of which are red. The humeri and scutellum are also reddish as are the legs with the exception of the apical fourth of the femora and the tarsi which are black.

The type is in the Mus. Comp. Zool. labelled Cuba (Poey).

This is the largest species of *Andrenosoma* so far found in Cuba. Banks gives the length as 23 mm. There is, however, a specimen in the Gundlach collection at Habana which is considerably larger.

***Andrenosoma quadrimaculata* new species.**

(Plate I, Fig. 19).

Male. Total length 20 mm. Black species with very hairy legs. 6th segment of abdomen and following segments reddish.

Proboscis and antennæ black. Face reddish, covered thickly with white pile. Mystax composed of thickly set, stubby, black bristles. Palpi black with black hairs. Beard white. Thorax deep reddish with two sparse median black lines and two large lateral spots on each side. The reddish areas as well as the pleuræ are covered with a silvery bloom. Hair and posterior bristles of mesonotum black. Pleuræ and coxæ thickly covered with sordid white hair. Legs black, except base of femora, and basal half of tibiæ and posterior femora which are deep red. Legs thickly covered with long fine pile, mostly white on reddish areas and black on black areas. On the anterior tibiæ a row of fine black bristles on the anterior dorsal aspect. Scutellum black with black hairs and a row of black bristles along margin. Wings hyaline at base, the apical half brownish, darkest along the veins. 1st posterior cell open. Halteres yellow. Abdomen with black hairs and bristles. Ground color of first 3 segments deep reddish; the 4th and 5th nearly black with, however, a deep reddish tint. 6th segment and following light reddish with fine reddish hairs. Genitalia with a few black bristles. The 1st two segments are covered thickly posteriorly and lightly anteriorly with short fine white appressed pile.

Holotype, ♂, Cuba (Poey), Loew collection in M. C. Z. This specimen bore the manuscript name of *quadrimaculata* which was adopted.

***Andrenosoma crassa* new species.**

(Plate I, Figs. 11 and 13).

Length 16-21 mm. A large, robust, black species, with the usual thoracic markings on the mesonotum obscure, brownish pollinose. The 6th and following segments of the abdomen are deep brownish red.

Male. Head black; (Fig. 9), mystax, palpal hairs, antennal bristles, bristles of vertex and occiput black. Hairs on sides of mystax and face as well as beard, white. Thorax black with black hairs and bristles, the indentations brownish pollinose. Legs black with black hairs and bristles. The first two coxæ have white hairs in front and the under side of the front and middle femora and tibiæ are thickly clothed with long fine white pile. Scutellum black with black hairs and long upturned marginal bristles. Wings tinged with brownish, darkest along veins, base nearly hyaline. 1st posterior cell open. Halteres brown. Abdomen black with black hairs, the 6th and following segments deep brownish-red with reddish hairs. Genitalia with reddish hairs and black bristles.

Female. With beard somewhat blackish, and lacking the white pile on the legs. Ovipositor long and cylindrical.

Holotype, ♂, Camaguey, Cuba, Aug. 20, 1924. (J. Acuña, Coll.). Allotype, ♀, same data. Seven paratopotypes, same data.

Andrenosoma acunai new species.

(Plate I, Fig. 7).

Male. Total length 10 mm. Small black species with reddish orange abdomen.

Antennæ, proboscis and palpi black. Occiput and frons silvery pruinose. Beard and mystax white, scanty, the latter with an occasional black bristle. A pair of long fine black hairs on occelar tubercle. Palpal hairs black. Thorax black. Posterior margins, a spot in front of wing and anterior angles of mesonotum silvery pruinose. Legs black with fine whitish hairs. Tarsi with black hairs. Wings suffused with light brownish tinge; costal, 2nd basal and base of marginal cells nearly hyaline. 1st posterior cell closed at margin. Halteres yellowish. Abdomen reddish-orange, except anterior portion of 1st segment and genitalia which are black.

Holotype, ♂, Camaguey, Cuba, Aug. 20, 1924 (J. Acuña, coll.).

ASILINÆ.

Key to the Genera.

- A. Arista of antenna pectinate *Ommatius*
- AA. Arista bare.
 - B. Posterior branch of third vein terminating a considerable distance behind the apex of the wing.
 - C. Hairy, robust species; hypopygium and ovipositor small and inconspicuous *Mullophora*
 - CC. Slender species; hypopygium large and ovipositor long *Asilus*
 - BB. Posterior branch of 3rd vein terminating at or before the apex of the wing (in some species of *Erax* very slightly behind apex).
 - D. Posterior branch of 3rd vein bending forward sharply before the apex of the wing; hypopygium normal in size; ovipositor cylindrical with terminal circlet of spines *Proctacanthus*
 - DD. Posterior branch of 3rd vein curved back slightly at tip; hypopygium enlarged; ovipositor long and compressed, without spines *Erax (aestuaus group)*

Ommatius Wiedemann.

Typical Species: *O. marginellus* Fabricius. W. Indies.

Ommatius marginellus Fabricius.

Asilus marginellus Fabr. Species Insect. II, 404, 22, 1781 et Mantissa Insect., II, 360, 25.

A grayish species with yellowish legs, the apices of the femora and posterior tibiæ brownish. Middle and posterior tarsi brown. There is a bulge in the costa in the male. The margin of the scutellum bears two bristles which distinguishes the species from the North American species *tibialis* Say.

Specimens at hand from Habana Province and Guantanamo.

Mallophora Macquart.

Typical Species: *M. bomboides* Wied. N. America.

Key to the Species.

1. Femora reddish; 1st four abdominal tergites and all of venter with thick yellow pile *macquartii* Rondani
2. Femora black; 1st two abdominal tergites with light yellow or white pile; venter black *bruneri* new species

Mallophora macquartii Rondani

(Plate I, Fig 10).

Mallophora scopifer Macquart, Dipt. exot. I (2), 89, 1838, nec Wied. Auss. Zweifl. I, 478, (1828).

Mallophora scopipeda Rondani, Nuov. Annal. Sci. Nat. Bologna, 367, (1850).

Mallophora macquartii Rondani Nuov. Annal. Sci. Nat. Bologna, Sec. 3, 11, 371, 21, (1850).

Length 15-20 mm. This black and yellow, bumblebee-like species is abundant in Cuba during May and June. Specimens are at hand from Santiago de Las Vegas, and Camaguey Province collected by S. C. Bruner and others, and from Guantanamo collected by Dr. Ramsden.

This species feeds very largely on honey-bees, occasionally taking a small *polistes* or other wasp or a small scarabeid beetle.

Dr. Bruner writes under date of June 5, 1928, "*Mallophora macquartii* appeared late. I did not take any until May 18, but they were probably out sooner. A few days later they were found in great numbers around the apiary, many of them were carrying honey bees. In fact, I did not see them with any other insect. They must kill a very large number of bees." In this respect they agree with our North American species, *M. orcina* Wied. and *M. bomboides* Wied., both notorious "bee-killers" in the Southern States. *Mallophora ruficauda* Wied. very abundant in the vicinity of Buenos Aires, Argentina, is recorded by Dr. Andres Copello as feeding very largely on honey-bees and a species in western U. S., *M. faultrix* O. S. also has the same habits.

Mallophora bruneri new species.

Length, 22-25 mm. A beautiful black species with whitish pile on the scutellum, the median portions of the first and second abdominal segments, occiput, beard and lower portion of mystax, quite distinct from any species previously described. All the white hairs have a faint yellowish tinge.

Female. Head black, sides of face brownish pollinose. Mystax with black bristles above and on sides, white bristles in center and below.

Bristles of antennæ and vertex, black. Palpal hairs, both black and whitish. Beard and occipital hairs whitish. Thorax deep black with black hairs, except the thick conspicuous tuft on scutellum and a tuft in front of the halteres, white. Legs piceous, the base of the tibiæ dark reddish brown, hairs and bristles black. Wings dark brown. Halteres dark brown. Abdomen deep black with black hairs. A narrow median band of white hairs on 1st and second tergites. A few white hairs on sides of 3rd tergite.

Holotype, ♀, Sierra Rangel, Pinar del Rio, Cuba, Aug. 29, Elevation 1500 ft. (in pine grove) S. C. Bruner and J. Acuña. Paratopotype, ♀, same data.

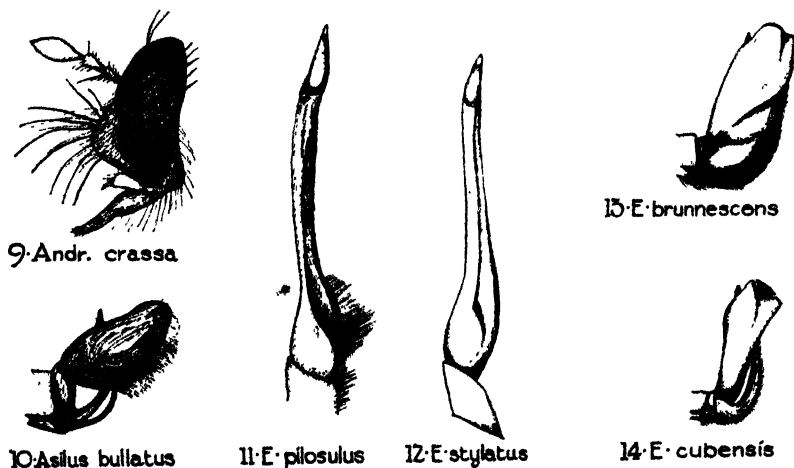


Fig. 9, Head of *Andrenosoma crassa* n. sp. Fig. 10, Male genitalia of *Asilus bullatus* n. sp. Fig. 11, Ovipositor of *Erax pilosulus* n. sp. Fig. 12, Ovipositor of *E. stylatus* Fabr. Fig. 13, Male genitalia of *E. brunnescens* n. sp. Fig. 14, Male genitalia of *E. cubensis* n. sp.

Asilus Linn.

Typical Species: *Asilus crabroniformis* L.—Europe.

Three species of *Asilus* are known to occur in Cuba. Their closest affinities seem to be with the *Pachychoeta* group of S. America. The latter is a genus bridging *Asilus* and *Erax*.

Asilus bullatus new species.

(Plate I, Fig. 14).

Length 9–13 mm. A small gray and black, *Erax*-like species with enlarged hypopygium (with tuft of white hairs below) and golden mystax in the male, and long, slender somewhat compressed ovipositor, and paler mystax in the female. In the ♂, the antennal arista is very slightly thickened preapically, but this does not occur in the ♀.

Male. Head slightly broader than thorax; antennæ dark brown; face golden pruinose, mystax golden with 2 or 3 long black bristles in upper part. Beard white. Palpal hairs, occipital bristles black. Thorax grayish pollinose, the mesonotum with a median black line and two black lateral spots on each side. Bristles black. Scutellum gray pollinose with black hairs and at least two long black marginal bristles. Coxal hairs and tuft in front of halteres pale yellowish. Legs black; tibiæ except tips, red. Wings hyaline, halteres yellowish. Abdomen black, margins of segments gray. Fine hairs whitish and strong bristles on lateral posterior borders of each segment pale yellowish. Hypopygium greatly enlarged, much wider than 7th segment, black with black hairs. A tuft of long whitish hairs on under side. (Fig. 10).

Female. Similar, the mystax paler. The ovipositor slender, black, somewhat compressed, nearly as long as segments 5, 6, and 7 together.

Holotype, ♂, Santiago de Las Vegas June 18, 1921 (B. T. Barreto). Allotype ♀, Rio Almend, June 3, 1924 (F. Cervéra). Paratypes 5 ♂♂, Banes, March 21, 1926 (Dr. J. Bequaert); "Cuba" (M. C. Z.); Cuba, vic. of Habana, (T. Barbour); 4 ♀♀, "Cuba" (M. C. Z.).

***Asilus ramsdeni* new species.**

Length 10 mm. Similar to the preceding, but the mystax is white, the legs all black, and the genitalia has a tuft of black, not white hairs, below.

Holotype, ♂, Tiguabos, Guantanamo, Cuba, Aug. 10, 1915 (Dr. Ramsden). Also an abdomenless specimen ($\frac{175}{96}$) in the Loew Collection, labelled "Cuba, Gundlach."

***Asilus loewi* new species.**

Length 11 mm. Similar to *bullatus*, but the mystax is white, not golden, the femora and tibiæ (except tips which are black) are yellowish brown. The claspers are yellowish brown not black, are produced below, and lack the tuft of white pile.

Holotype, ♂, "Cuba, Poey," (96) Loew Coll. (M. C. Z.).

***Erax* Scopoli.**

Typical Species: *E. rufibarbis* Macquart. North America.

Key to the Species.

- | | |
|---|---------------------------|
| 1. Mystax pale..... | 2 |
| Mystax at least partly black | 3 |
| 2. Mystax straw yellow; hypopygium short and thick..... | <i>nigrilaris</i> Hine |
| Mystax white; hypopygium long and narrow..... | <i>portoricensis</i> Hine |
| 3. Large robust species..... | 4 |
| Smaller species..... | 5 |

4. Dark gray species; a tuft of black hair at base of ovipositor on under side. *pilosulus* new species
 Lighter gray species; ovipositor without such a tuft; male with hypopygium much enlarged and with costa thickened and dilated beyond middle of wing. *stylatus* Fabricius
5. Brownish species *brunnescens* new species
 Blackish or grayish species 6
6. Dark, slatey colored species, distinctly marked; hypopygium short, broad and shining black *rufitibia* Macquart
 Small greyish species, hypopygium elongate *cubensis* new species

In addition, the following species, occurring in the West Indies, although as yet unrecorded from Cuba may occur on this island.

nigrimystaceus Macq. 17 mm. Mystax black and yellow; costal border of wing slightly dilated, hypopygium, short, broad, black, with two minute emarginations at apex, one dorsal and one ventral. Related to *rufitibia* but differing in conformation of the hypopygium. *Dominica*.

fulvibarbis Macq. 25 mm. Rusty brown pollinose, mystax black above, yellow below, Hypopygium very long. Hind femora with 6 or 7 strong black bristles on outer side. *San Domingo*.

haloesus Walk. 18 mm. Mystax white with heavy black bristles, beard white, scutellum with white hairs on disc and slender black bristles on margin, costa not thickened, hypopygium elongate, reddish at tip. *Jamaica*.

***Erax nigratarsis* Hine.**

Erax nigratarsis Hine, Annals Ent. Soc. Amer., Vol. XII, No. 2, p. 129, June, 1919.

Length 18 mm. Described by Hine as a gray pollinose species with mystax, beard, and hairs of the palpi all light colored. Femora black, tibiae, except apex, yellow, tarsi intensely black. "Genitalia short, somewhat tumid from side view, narrowed from the middle towards apex when it is truncate."

The type is from Holguin, Cuba, Dec. 19, 1904, collected by H. S. Parish.

***Erax portoricensis* Hine.**

Erax portoricensis Hine, Annals Ent. Soc. Amer., Vol. XII, No. 2, p. 128, June, 1919.

Length 21 mm. Distinguished by the long, black, slender hypopygium, white mystax, palpal hairs, and beard; and the costal border not dilated.

One male, Rio Seco, San Carlos Estate, Guantanamo, Cuba, July 4, 1915 (Dr. C. T. Ramsden).

***Erax brunnescens* new species.**

(Plate I, Figs. 6 and 9).

Total length 15–21 mm. A light brown pollinose species.

Male. 1st two segments of antennæ black with black hairs, rest missing. Face very light yellow pollinose; mystax, beard, palpal and occipital hairs straw-colored. A few black bristles on occiput, vertex and upper part of mystax. Thorax yellowish-brown pollinose with a darker median stripe and lateral spots. Hairs and bristles on disk of thorax and scutellum black. Hairs of pleura light. Femora black with long, dense light yellow hairs; meso- and meta-femora with a few black spines in rows. Tibiæ reddish with light yellowish hairs and black spines, nearly black at the tip. Tarsal segments dark reddish, blackish towards tips. Wings with brownish tinge, the costal border not appreciably dilated. Halteres brownish. Abdomen light brownish pollinose, 6th and 7th segments silvery. Genitalia as in Fig. 13.

Female. Similar to male. Ovipositor black.

Holotype, ♂, Guantanamo (at light) May 10, 1917. (Dr. C. T. Ramsden); allotopotype, ♀, June 3, 1917, (Dr. C. T. Ramsden). 2 Paratopotypes ♂♂, May 14 and May 26, 1917 (Dr. C. T. Ramsden).

***Erax stylatus* Fabricius**

(Plate I, Figs. 1 and 4).

Asilus stylatus Fabricius, Syst. Ent. 795, (1775)

Asilus caudex Walker, List Dipt. Brit. Mus. 11, 404, (1849).

Erax invarious Walker, Ins. Saundersiana, Dipt. I, 131, (1851)

Length, 20–28 mm. A large, common, grayish species, distinguished by the great black hypopygium and dilated costal border in the male and the long, bare ovipositor in the female. (Fig. 12). The femora are black, tibiæ, except tips reddish yellow. Mystax composed of black bristles and white hair.

Numerous specimens from Habana Province collected by S. C. Bruner and others. April–July. A female taken at Santiago de Las Vegas, May 24, '27 by S. C. Bruner was feeding on a male of the common "bee-killer" *Mallophora macquartii*, the prey considerably exceeding in bulk that of its captor—a remarkable instance of an Asilid which can overpower such a formidable insect as a honey-bee, falling prey to one of its relatives which at first sight would seem to be much weaker. So far as is known *Erax stylatus* does not feed on honey-bees, but confines its attacks to other diptera, small coleoptera, hemiptera, and lepidoptera and probably other small insects. Its longer legs and more rapid flight no doubt enable it to seize

and overcome the more bulky *Mallophora*. Dr. Bruner in a letter dated June 5, 1928, also reports the capture of a female *stylatus* Fabr. feeding on the Cicindellid, *Cicindella viridicollis* Dej.

***Erax pilosulus* new species.**

Length 29 mm. A large gray species related to *stylatus*, but distinguished by the tuft of black pile at the base of the under side of the ovipositor.

Female. Head black; antennæ, occipital bristles, bristles of vertex, mystax and palpi all black. Face grayish brown pollinose. Beard composed of fine sordid white hairs. Thorax gray pollinose with intense black median line and lateral spots. Hairs and bristles black. Scutellum gray with black hairs and bristles. Femora, tips of tibia and tarsi intense black, rest of tibia reddish. Wings tinged with brown; stump vein absent. Abdomen black (greased) apparently the margins of the segments were originally gray. Ovipositor shining black, longer than segments 5, 6 and 7, base on under side with tuft of black hair. (Fig. 11).

Holotype, ♀, Sierra Maestra, Cuba, July 10-20, 1922. Coll. C. H. Ballou and S. C. Bruner 1070-1350 m. (Palma Mocha).

***Erax rufitibia* Macquart.**

(Plate I, Fig. 18).

Erax rufitibia Macquart, Dipt. Exot. Suppl. 3, 27, 42, tab. 11, Fig. 11, (1848).

?*Erax fortis* Walker, List Dipt. Brit. Mus. VII, 623, (1855).

Length 18-21 mm. A rather blue-gray pollinose species with mystax and palpi mostly black haired, scutellum with black hair, tibia except tips reddish yellow, tarsi, deep red nearly black, femora black. Genitalia short, black, thick, 6 and 7th segments silvery. Costal border only very slightly dilated.

♂ ♂, Cuba, Gundlach, 15/44 Loew Coll. (M. C. Z.); "Cuba" vicinity of Habana (T. Barbour). ♀ ♀, Casa blanca, Habana, June 27, '26, (S. C. Bruner); Guantanamo, Cuba, June 20, 1915 (C. T. Ramsden).

***Erax cubensis* new species.**

Length 15-17 mm. A small grayish species with elongate hypopygium which is reddish at tip and notched as in Fig. 14.

Male. Antennæ black, the 1st segment with whitish hairs beneath. Mystax composed of black and white hairs intermingled. Palpi with black hairs; beard white; occipital bristles black. Thorax brownish-gray pollinose, with median black line and three lateral spots on each side on mesonotum. Hairs and bristles of mesonotum black. Scutellum gray pollinose with white hairs and black marginal bristles. Femora

black with coppery reflections, tibiae and tarsi pale brownish yellow. Tips of tibiae blackish. Wings nearly hyaline with faint yellowish tint, costal margin not dilated. Stump vein shorter than its base. Abdomen black, the lateral and outer portion of the posterior margins of the segments white, segments 5, 6, and 7 silvery. Hypopygium longer than $5 + 6 + 7$, slender, blackish with black hairs, the tip reddish. Fig. 13.

Female. Similar, but segments 5, 6, and 7 not silvery. Ovipositor black.

Holotype, ♂, Soledad, Cuba, June 21, 1925, J. C. Myers. in M. C. Z. Allotype, ♀, Soledad, April 6, 1926 (Dr. J. Bequaert); paratypes ♀ ♀, Soledad, May 22, 1925 (Geo. Salt); no. 251 Loew Coll. (M. C. Z.); Soledad, April 6, 1926 (Dr. J. Bequaert).

Proctacanthus Macquart.

Typical Species: *P. philadelphicus* Macquart. North America.

Only one species of this genus represented by a single specimen occurs in the collection.

Proctacanthus vittatus (Olivier).

Asilus vittatus Olivier, Encyclop. Methodique IV, 263, 4, (1789).

Proctacanthus rufiventris Macquart, Dipt. Exot. I, 2, 123, (1838).

A bright colored species with reddish-yellow legs and abdomen. The tarsi (except hind metatarsus which is reddish) and the base of the abdomen (1st segment and anterior half of second) are black. Mystax and pile of scutellum and along base of abdomen, golden. The palpi are yellow haired with one or two black bristles.

A small male (23 mm.) from Cayo Rosario, April 3, 1926, collected by F. Cervéra.

The synonymy of *P. rufiventris* I have discussed in a previous paper. Psyche, vol. XXV, no. 1, p. 14, 1928.

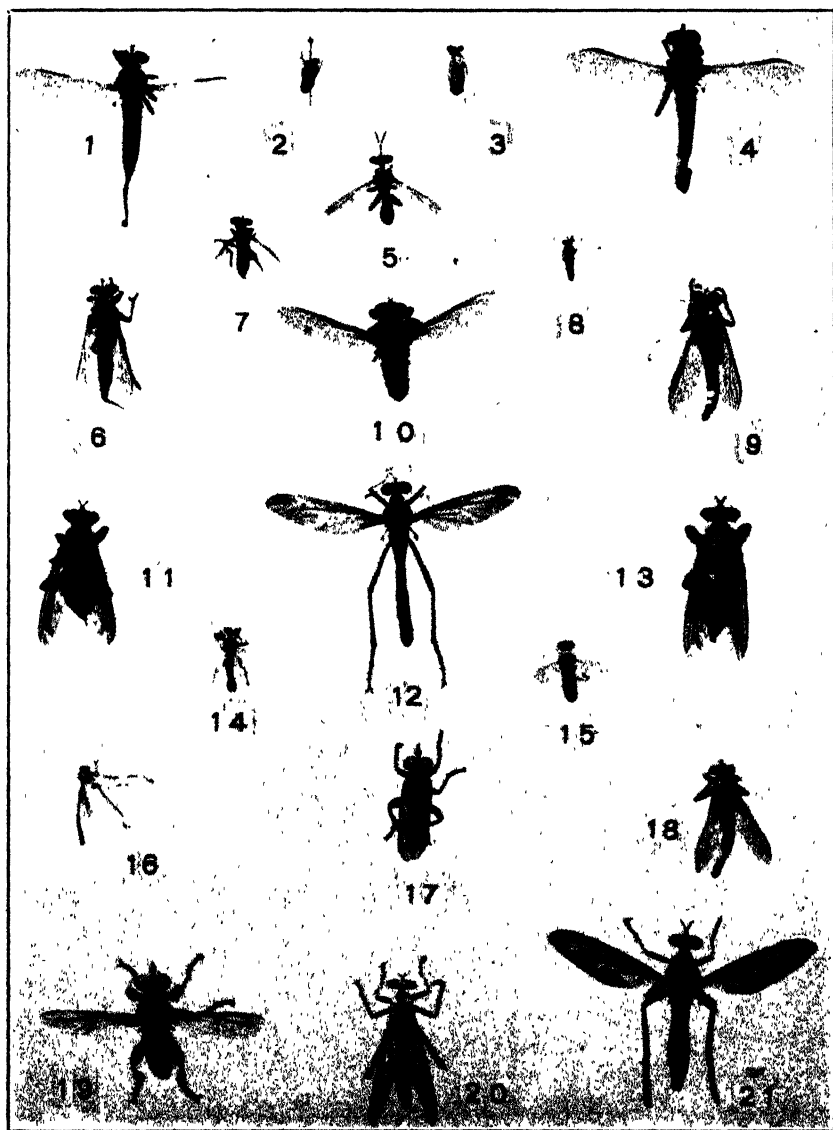
Eccritosiæ plinthopyga Wiedemann (Dipt. Exot. 184. 4. (*Asilus*) 1821) described from Cuba, I have not seen. The ♂ is described as 11 $\frac{1}{2}$ lines in length (24 mm.), brownish, the base of the abdomen black and the apex testaceous, legs black. The beard and mystax are white, the scutellum fuscous, yellow-haired. The abdomen is described as having segments 1 and 2 all black with the sides white-haired, the 3rd black with the incisures testaceous, the 4th testaceous with a black triangular spot at the base; segments 5-7 all testaceous.

Eccritosiæ is distinguished from *Proctacanthus* by the abdomen being broad at the base, tapering sharply to the tip, and much shorter than the wings.

EXPLANATION OF PLATE I.

(Natural Size).

- | | |
|---|---|
| Fig. 1. <i>Erax stylatus</i> Fabricius, ♀. | Fig. 12. <i>Plesiomma indecorum</i> Loew, ♂. |
| Fig. 2. <i>Cerotainia laticeps</i> n. sp., ♀. | Fig. 13. <i>Andrenosoma crassa</i> n. sp., ♂. |
| Fig. 3. <i>Atomosia pubescens</i> n. sp., ♂. | Fig. 14. <i>Asilus bullatus</i> n. sp., ♂. |
| Fig. 4. <i>Erax stylatus</i> Fabricius, ♂. | Fig. 15. <i>Atomosia similis</i> Bigot, ♂. |
| Fig. 5. <i>Rhopalogaster bella</i> n. sp., ♀. | Fig. 16. <i>Leptogaster obscuripes</i> Loew, ♂. |
| Fig. 6. <i>Erax brunnescens</i> n. sp., ♀. | Fig. 17. <i>Andrenosoma chalybea</i> Williston, ♂. |
| Fig. 7. <i>Andrenosoma acunai</i> n. sp., ♂. | Fig. 18. <i>Erax rufitibia</i> Macquart, ♂. |
| Fig. 8. <i>Atomosia parva</i> Bigot, ♂. | Fig. 19. <i>Andrenosoma quadrimaculata</i> , n. sp., ♂. |
| Fig. 9. <i>Erax brunnescens</i> n. sp., ♂. | Fig. 20. <i>Deromyia ternata</i> Loew, ♂. |
| Fig. 10. <i>Mallophora macquartii</i> Rondani, ♀. | Fig. 21. <i>Blepharepium annulatum</i> Bigot, ♂. |
| Fig. 11. <i>Andrenosoma crassa</i> n. sp., ♀. | |



HOMOLOGIES OF TRACHEAL BRANCHES IN THE NYMPH OF ANAX JUNIUS BASED ON THEIR CORRELATION WITH THE MUSCLES THEY SUPPLY.

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Very few attempts have been made to homologize the tracheal branches in insects.

Chapman (3) homologized the tracheal branches of the thorax in the winged insects. Kennedy (9) homologized the principal tracheal branches of the Zygopterous nymph as referred back to the simple system of a primitive segment. The forking of the tracheal branches was used largely by him in determining their homologies in the system. The writer has carried this a step farther in the Anisoptera by tracing the branches out to the somatic muscles which they supply.*

This correlation between the muscles and the tracheal branches supplying them, together with the forking of the branches, enables us to carry further their homologization if we believe that in the evolution of the insect the main tracheal branches at least, do not forsake the muscles to which they first ran.

Kennedy (9) and others, have shown that when the pleural folds on the thoracic segments of early instar naiads move up and later develop into wings, the tracheal branches supplying the folds accompany them. Another proof of the faithfulness of a branch to the organ which it supplies, is illustrated by the ganglionic tracheæ of the anterior abdominal segment. These branches accompany the ganglion of the first abdominal segment when it migrates into the thorax and joins the meta-thoacic ganglion.

Goodrich (7) has shown that nerves are faithful to the muscles in the limbs to which they run. In speaking of the jugular pelvic fins of the Codfish which have moved to their position in front of the pectorals, he says, "These limbs do not really lose their original connections, the displacements can be

*This work was done at the Ohio State University, 1926-1927, under the direction of Dr. C. H. Kennedy.

traced in ontogeny and the nerve supply in the adult infallibly betrays its course." "That a motor nerve is unable to forsake the muscle in connection with which it was originally developed to become attached to some other, seems to be in the highest degree probable, both on anatomical and physiological grounds." This does not necessarily prove that the tracheal branches have similar characteristics but it may indicate the possibility that such is the case.

Undoubtedly the best way to homologize the tracheal branches is to trace their evolution through a complete series of dissections starting with their first development in the embryo and continuing through each nymphal instar, as Nelson (12) has done with the honey bee, for example. However, this method was not attempted in the present work which is confined entirely to the abdomen of the *Anax junius* nymph.

The writer realizes that this prevents as accurate a homologization of tracheal branches as would be possible had the work in the thorax and head been completed, or had Nelson's method been followed; hence only those homologies which seem fairly obvious are discussed.

Variations and abnormalities in the smaller tracheal branches occur quite commonly and the readiness of the system to develop new branches makes the homologization of them impossible unless enough specimens are dissected to enable us to find the type most characteristic. Some of these abnormalities may give us valuable clues in homologizing the more specialized branches. Approximately fifty late instar nymphs were dissected in the present work.

NOMENCLATURE.

The nomenclature used for the tracheal branches in this paper is that worked out by Chapman (3) and Kennedy (9) with a few additions by the writer.

Whedon's (15) terminology for the muscles is used in most instances although some minor changes and additions have been made, and a few original names added for the muscles not figured by him. Attention will be called to these muscles as they are described.

No attempt was made to homologize the muscles of *Anax junius* with those of Orthopteroid insects as worked out by Ford (6). This was left for someone more familiar with the musculature of the various groups.

MUSCULATURE OF THE ABDOMEN.

(Figure 1).

Before attempting to homologize the tracheal branches in the abdomen of *Anax junius* and correlate them with the muscles a description of the abdominal musculature is necessary.

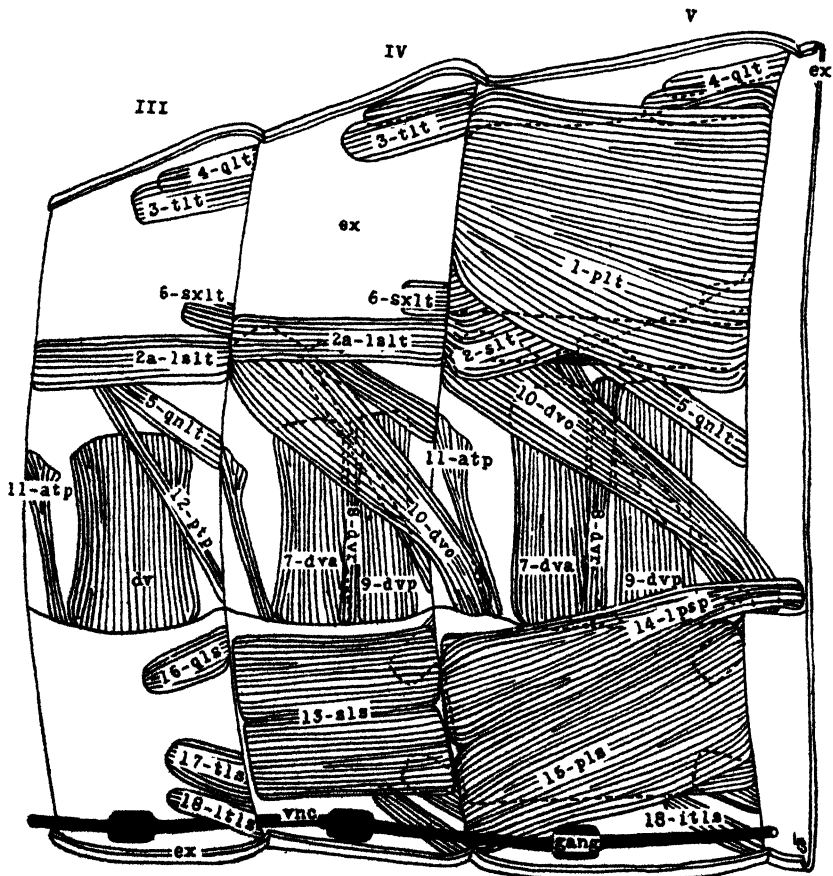


Fig. 1. Lateral view showing musculature in right half of abdominal segments three, four, and five of a male *Anax junius* nymph. Only the external layers of muscles are shown in segments III and IV. In segment V the musculature is complete. (See page 308 for explanation of terms.)

"The muscular system of the Aeshnid nymph is probably the most complex system among the various sub-families of the Odonata." (Whedon (15)).

It might be of interest to the reader to know that Miss Ford (6) found in the Odonata a marked difference between the musculature of nymphs and imagoes. She found that in the transition from nymph to adult it was the inner layer of muscles which disappeared leaving the shorter and smaller muscles of the outer layer.

Only the muscles of segments three, four, and five are shown in the Fig. 1 but these may be taken as representative of the other abdominal segments excepting one and ten. Some variation in point of insertion and size occurs among the muscles in the various segments as might be expected. In segments one and ten there is considerable specialization due to the junction with the thorax and the attachment of the caudal appendages respectively.

As Whedon (15) has already described and named the abdominal muscles in the nymph of *Anax junius* only a brief description will be given. The writer has considered as a separate muscle any group or layer of muscle fibers having its point of origin or insertion distinct from that of any other layer which might or might not be in contact with it.

The Tergal Musculature.—The Primary Longitudinal Tergal Muscles (1-plt) lie ventral to all the remaining tergal muscles and are narrowest at the anterior end. Their origin is on the anterior margin of the tergum and they diverge caudad to insert on the suture fold.

The Secondary Longitudinal Tergal Muscles (2-slt) lie dorsal to and in contact with the Primary Tergals but they converge caudad and are narrowest at the posterior end.

The Lateral Secondary Longitudinal Tergal Muscles (2a-lslt) (not figured by Whedon) have their origin external to the Secondary Tergals at their lateral anterior margin and insert upon the suture fold external to the posterior lateral margin of the Primary Tergals. This Lateral Secondary Tergal crosses the fibers of the other Tergal Longitudinal Muscles at an approximate angle of 30°. Whedon and others may have considered this a part of the Secondary Tergal. It is found in segments two to eight inclusive.

The remaining Tertiary (3-tlt), Quaternary (4-qlt), Quinary (5-qnl), and Sextic (6-sxt) Longitudinal Tergal Muscles have their origin on the face of the tergite and extend caudad to insert on the anterior margin of the suture fold. They vary in

length and thickness between themselves and in the various segments, being shortest and widest (excepting 6-sxlt) in the anterior segments and becoming longer as the segments become lengthened. The Sextic Longitudinal Tergal Muscle (6-sxlt) decreases in size toward the posterior end of the abdomen and in segment nine it inserts on a sharp pointed apodeme projecting forward from the anterior margin of the tenth segment.

The Sternal Musculature.—The Primary Longitudinal Sternal Muscles (15-pls) correspond to the Tergal Muscles of the same name except that they are much narrower. The attachment is the same and they occur in segments two to eight inclusive lying dorsal to the Secondary Longitudinal Sternals (13-sls).

These latter run parallel to the nerve cord, are of uniform width and are much thinner than the Primary Sternals. They also appear to be divided into two parts in the larger segments.

The Lateral Primary Longitudinal Sternal Muscles (14-lpsp) have their origin on the suture fold anterior to that of the Primary Longitudinal Sternals. In segments one to three inclusive they insert upon the anterior aspect of the suture fold of the following segment. In segments four to seven inclusive they narrow at the posterior end crossing laterally over the pleural suture to insert upon the inner anterior portion of the pleurite. In segment eight they are the same as in the first three segments. In segments nine and ten they become more specialized as do all the other muscles.

The Tertiary Longitudinal Sternal Muscles (17-tls), Inner Tertiary Longitudinal Sternal Muscles (18-itls), and Quaternary Longitudinal Sternal Muscles (16-qls), all have their origin on the floor of the sternum and insert on the anterior portion of the suture fold.

The Vertical and Oblique Muscles.—The Dorso-ventral Segmental Muscles (dv-) occur in all the segments except the tenth. In the first three they exist as single muscles with their origin covering a broad lateral line on the tergum. In segments one and nine these insert on the sternum, and in the intermediate segments on the inner margin of the pleurite. Beginning in segment four (Whedon says five) this muscle splits up into a Dorso-ventral Segmental Muscle, anterior part (7-dva), the Dorso-ventral Respiratory Muscle (8-dvr) (Whedon's dvs), and the Dorso-ventral Segmental Muscle, posterior part (9-dvp). These muscles reach the greatest size in segments five, six, and seven.

The development of the Dorso-ventral Respiratory in the region of the rectal gills is especially interesting. This muscle is more delicate than the other two and runs slightly oblique, having its point of origin higher on the tergum and its insertion farther forward on the pleurum. It is very heavily tracheated and seems to play the important part in the rhythmical abdominal respiratory movements. The other dorso-ventral muscles including the Dorso-ventral Oblique (10-dvo) no doubt are used chiefly to force the water from the abdomen in the sudden forceful expulsions characteristic of the nymph while swimming.

The Dorso-ventral Oblique Muscles (10-dvo) have their point of origin on the lateral anterior margin of the tergum, posterior and slightly lateral to the origin of the Lateral Secondary Tergals. Whedon speaks of these muscles as inserting on the anterior lateral corner of the pleurite and suture fold of the following segment in segments one to nine. The writer found this to be true in segments four to seven inclusive, but in segment eight the muscle was totally absent and in segments one, two, three, and nine it had its insertion on the anterior aspect of the suture fold, not reaching into the following segment.

The Anterior Tergo-pleural Segmental Muscle (11-atp) (not figured by Whedon) occurs in segments 1-9 and is very delicate. It has its origin in an oblique line on the anterior lateral face of the tergum and narrows ventrally to insert just anterior to the Dorso-ventrals.

The Posterior Tergo-pleural Segmental Muscle (12-ptp) (not figured by Whedon) occurs in segments 2-9 inclusive. It has its origin near that of the Quinary Longitudinal Tergal and posterior to that of the Dorso-ventral Oblique Muscle. The latter muscle when in place, covers the former at its point of intersection on the suture fold. They both pass to the inside of the Dorso-ventral.

METHOD OF CORRELATING THE TRACHEAL BRANCHES WITH THE PARTS SUPPLIED AIR.

Scott (13), Tillyard (14), and others have described the main tracheal trunks and their connections so we need not go into the details here.

By referring to Fig. 1 and Plate I the reader can connect the branches up to their respective muscles with the aid of the numbers.

Stippling within a branch was used to designate the part in contact with the exoskeleton. The extent of the tracheation of the hypodermal layer on the body wall was surprising. Evidently some respiration or interchange of gases takes place through the body wall for it does not seem as if the hypodermal cells would need so extensive a system in their secretion of the chitinous layers preceding ecdyses.

Many branches too small or not constant enough in their source or position, running to the exoskeleton as well as muscles, were not illustrated. Only the branches which the writer could depend on as being present in the majority of cases and were known always to run to the same muscle, were figured.

Wherever a number is found, does not necessarily mean that that particular muscle is the only one in contact with the trachea. The branch may cross over, under, or even run through the muscle and into another or it may lie between two muscles. All kinds of possibilities exist. Often times a branch lying on the body wall will have smaller branches starting in muscles running to it, while its larger end turns in and connects with a main branch. In other words the number indicates the muscle with which the branch seemed most closely associated at that particular point.

THE HYPOTHETICAL PRIMITIVE TRACHEAL SYSTEM AND APPARENT HOMOLOGIES IN *Anax junius*.

(Text Figure 2 and Plate I).

It is now generally believed that the primitive tracheal system was segmental, originating from spiracular pits in the body wall. Grassi (8) and several other writers have demonstrated this. Nelson (12) in his study of the honey bee shows that in the ontogeny of the individual, the tracheal system first develops in this way as a segmental system and then later by fusion of its branches becomes a connected whole. The larger longitudinal trunks found in all the higher insects are thus proven to be secondary and not primary parts of the system.

The segmental unit as demonstrated in the embryo (Nelson p. 170) and by analysis in the Zygoterous nymph (Kennedy (9) consists of the following:

1. Spiracle.
2. Spiracular pit.
3. Spiracular trunk.....dorsad
4. Ganglionic trachea.....ventrad

Branches of the pit are:

5. Anterior spiracular connection.....cephalad
6. Leg trachea.....caudad

In the Odonata these have minor branches which are quite as definite as the main stems.

The above analysis differs slightly from that made by the writer. In *Anax junius* the leg trachea (lt ?) seems to have developed from the anterior spiracular connective (asc) and to turn cephalad instead of caudad. It will be necessary to go to the thorax or even to the embryology of the insect before this can be determined.

The writer has used a question mark in designating homologous parts about the origin of which there was considerable doubt. Tracheal branches or parts of branches figured in Text Fig. 2 and Pl. I, and considered homologous by the writer may be identified by the symbols drawn within them.

Because the segments figured in Plate I are probably the least specialized of any in the nymph they have been used as a starting point for constructing the hypothetical unit figured in Fig. 2. Anterior to them the system becomes modified by the proximity of the thorax. In the posterior end of the abdomen the development of rectal gills caused the tracheal branches to evolve to such an extent that it is almost impossible to homologize them. This shows up as far forward as segment six (Plate I).

Since the spiracle is the starting point for the development of the tracheal system in insect embryos it is the only logical point at which to start the hypothetical primitive unit.

From the Spiracle (sp) at the anterior margin of the segment there extends into the body wall of the primitive insect, a Spiracular Pit (spp). From the inner end of this pit there develops ventrad, the Ganglionic Trachea (gt) running to the ganglion of its segment. Turning forward from the ganglionic trachea is the Longitudinal Sternal Muscle Branch (lsg) supplying the sternal muscles at their posterior ends. Branching caudad from the ganglionic trachea is the Sternal Trachea (st) which extends into the next segment. Grassi (8) has shown that in *Machilis* the tip of this branch extends past the ganglionic trachea of the following segment. That these could easily fuse at this point to form the Sternal Trunk (st) in

Anax junius seems quite probable. By referring to *st* in segment VII Plate I we find that it has apparently fused with the tip of the longitudinal sternal muscle branch (*lsq*) of the ganglionic trachea in segment eight.

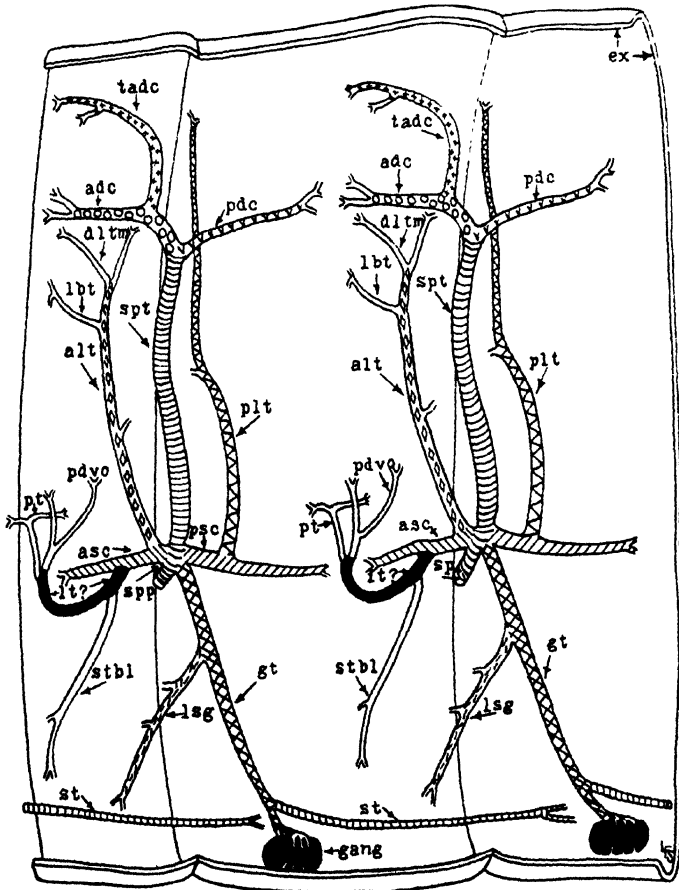


Fig. 2. Hypothetical, primitive segmental tracheal units. A series of such as these may have fused to form the present *Anax junius* tracheal system as shown in Plate I. (See page 308 for explanation of terms.)

From the bottom of the spiracular pit extends dorsad the Spiracular Trunk (spt). This branches and sends cephalad the Anterior Dorsal Connective (adc) from which extends

upwards to the heart and tergal muscles the so-called Tip of the Anterior Dorsal Connective (tadc). The caudal branch is the Posterior Dorsal Connective (pdc) which fuses with the anterior dorsal connective of the following segment to form the Dorsal Trunk (DT). Plate I.

It is interesting to note that in every segment except the eighth the ganglionic trachea (gt) still joins the ventral trunk (VT) at the junction of the spiracular pit, which would tend to indicate that it was the first and most important branch from the spiracular pit.

The spiracular trunk shifts a considerable distance from the pit connection in all the more specialized abdominal segments.

Extending cephalad from the base of the spiracular pit is the Anterior Spiracular Connective (asc). This gives off first, the Anterior Latero-tergal Trachea (alt) from which is sent the Lateral Branch to the tergum (lbt). Above this "alt" divides into a branch to the exo-skeleton and the Dorsal Branch to the longitudinal tergal muscles (dltm). The latter supplies the posterior and middle regions of the tergal muscles with smaller branches. *

From the anterior spiracular connective is also sent the Leg Trachea (lt ?) about which the writer is in doubt. This turns out into the pleural fold and divides sending cephalad the Pleural Tracheæ (pt) which run to the Dorso-ventral muscles and sending caudad the Pleural Branch to the dorso-ventral oblique muscle (pdvo). The Sternal Branch of the leg (?) trachea (stbl) lies on the floor of the abdomen and its tips extend into the Tertiary and Inner Tertiary Sternal muscles.

The anterior spiracular connective fuses with the Posterior Spiracular Connective (psc) to form the Ventral Trunk (VT) Plate I. The posterior spiracular connective (psc) (leg trachea-Kennedy) sends a branch, the Posterior Latero-Tergal (plt) to the body wall in the anterior part of the tergum. From it short branches extend into the tergal muscles.

Reference to Plate I will show that the pleural trachea (pt) has shifted onto the ventral trunk.

REMARKS.

Many interesting problems presented themselves in the course of this work. For instance, in segment five a well-developed respiratory muscle branch (rmb) appears with the development of the Dorso-ventral Respiratory muscle. In size and development it is closely correlated with that of this muscle. In segments five and six this branch extends dorsally and laterally over the Dorso-ventral Oblique muscle and then turns down between it and the dorso-ventral muscles. In segment seven it does not loop around the Oblique at all but enters the space between this muscle and the dorso-ventral muscles from the lower side.

The branching of the trachea in the posterior part of segment seven is very complicated. The spiracular trunk which should arise in segment seven near the spiracular pit is missing.

It will probably be necessary to go back to the embryology of the species before some of these problems can be solved.

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EXPLANATION OF PLATE I.

Lateral view showing homologies of the somatic tracheal branches in the right half of abdominal segments three to seven in a male nymph of *Anax junius*. Numerals indicate the particular muscles with which the branches come in contact at that point. Homologous branches, or parts of branches, may be identified by the symbols drawn within them. Compare with Text Fig. 2.

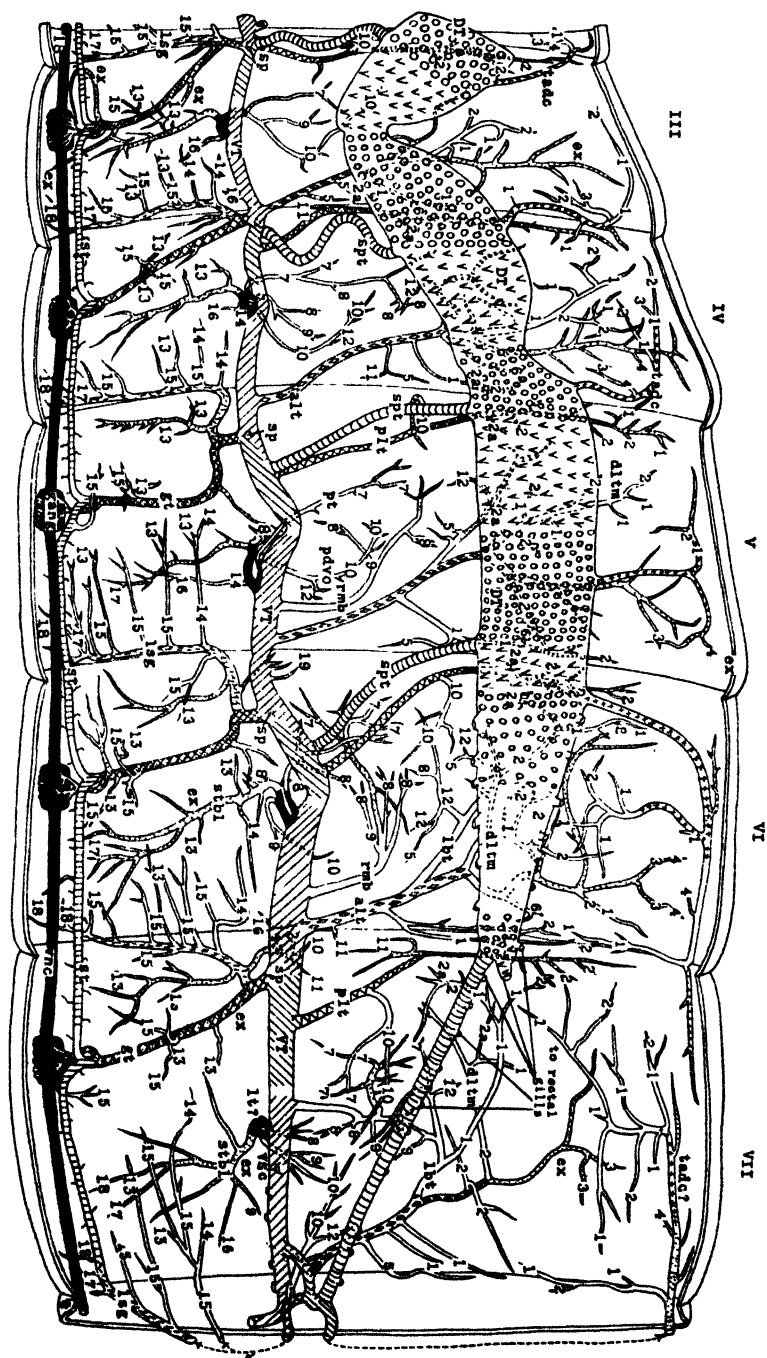
ABBREVIATIONS USED IN THE ILLUSTRATIONS.

RELATING TO MUSCLES.

- | | |
|---|---|
| 1-plt—primary long. terg. muscle. | 10-dvo—dorso-vent. oblique muscle. |
| 2-slt—secondary long. terg. muscle. | 11-atp—ant. tergo-pleur. seg. muscle. |
| 2a-lslt—lateral secondary long. terg. muscle. | 12-ptp—post. tergo-pleur. seg. muscle, (oblique). |
| 3-tlt—tertiary long. terg. muscle. | 13-sls—secondary long. sternal muscle. |
| 4-qlt—quaternary long. terg. muscle. | 14-lpsp—lateral primary long. sterno-pleur. muscle. |
| 5-qnl—quinary long. terg. muscle. | 15-pls—primary long. sternal muscle. |
| 6-sxlt—sextic long. terg. muscle. | 16-qls—quaternary long. sternal muscle. |
| 7-dvs—dorso-vent. seg. muscles, ant. pt. | 17-tls—tertiary long. sternal muscle. |
| 8-dvr—dorso-vent. respiratory muscle. | 18-itls—inner tertiary long. sternal muscle. |
| 9-dvp—dorso-vent. seg. muscles, post. pt. dv, dorso-vent. seg. muscle. (in abdominal segs. one, two and three). | 19—transverse muscle. |

RELATING TO TRACHEAL BRANCHES.

- | | |
|--|---|
| adc—anterior dorsal connective. | pdvo—pleural branch to dvo muscle. |
| alt—anterior latero-terg. trachea. | plt—posterior latero-tergal trachea. |
| asc—anterior spiracular connective. | psc—posterior spiracular connective. |
| dltm—dorsal branch to long. terg. muscles. | pt—pleural trachea. |
| dt—dorsal trunk. | rmb—respiratory-muscle branch. |
| ex—exoskeleton. | sp—spiracle. |
| gang—ganglion. | spp—spiracular pit. |
| gt—ganglionic trachea. | spt—spiracular trunk. |
| lbt—lateral branch to tergum. | st—sternal trachea. |
| lsg—long. sternal muscle branch from ganglionic trachea. | stbl—sternal branch of leg (?) trachea. |
| lt?—probable leg trachea. | tadc—tip of anterior dorsal connective. |
| pdc—posterior dorsal connective. | vnc—ventral nerve cord. |
| | vsc—visceral trunk. |
| | vt—ventral trachea. |



THE GENUS *ECPANTHERIA* (LEPIDOPTERA, *ARCTIDÆ*).

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The present paper is primarily to call attention to certain structural characters in the genus *Ecpantheria*, which have escaped the attention of previous revisers.

There are three surveys of the genus. Oberthür, in the "Etudes Entomologiques," fascicle 6, figures all of the forms known to him, many of them new, but unfortunately without any descriptions, or any notes whatever on structures, and without any indication which forms might be of specific and which of varietal status. Hampson, in the "Catalogue of the Lepidoptera Phalaenæ," vol. 3, p. 365, publishes a revision with some structural grouping, and with keys to the species. This is the only attempt to investigate structural characters, and unfortunately is surprisingly inaccurate. The antenna is made the primary character for subordinate grouping, but the antennæ are wrongly reported in a number of species, and the lobing of the hind wing, which is made the second character, is also incorrectly given in a couple. An attempt is made to reduce Oberthür's names, but some are sunk incorrectly, and others should perhaps be restored to varietal rank. In his "Supplement," vol. 2, pp. 445-455, the more recent species are added, but the errors of the original volume are not corrected. Finally Seitz, in the "Macrolepidoptera of the World," vol. 6, p. 315, goes over the genus, and figures most of the species. His grouping of the species is artificial, and structure is practically ignored.

The following analysis will bring out some of these characters, but is by no means the last word. In particular, the fore leg shows some variation, several species besides the new *E. chelifera*, showing some development of claws on the fore tibia, and the antenna showing considerable variation within the group without pectinations or definite serrations. Too many species are unknown to me to make the division at this time. The two series of species in which the second and fourth rows of

spots on the fore wing are reduced, are also undoubtedly related to each other, though one series has lobed and the other simple hind wings. It is not unlikely that some structure will yet be found to associate these.

The genus may be divided as follows:

- I. Antenna plumose, fore wing rather short and bluntly rounded, *albicornis* only
- II. Antenna shortly pectinate, the pectinations as long or twice as long as width of shaft; fore wing longer and more pointed *heterogena*, *mucina*, etc.
- III. Antenna serrate..... *deflorata*
- IV. Antenna faintly serrate toward apex and fasciculate or simple.
 - A. Hind wing with anal lobe well-marked, normally long; fore wing with second and fourth rows of spots much smaller than first, third and fifth, and solid black. *lata* etc.
 - B. Hind wing with anal lobe very long, bearing a yellow hair-pencil on under side; spots of fore wing ocellate, and all the rows similar, *nigriplaga*, *orsa*, etc.
 - C. Hind wing moderately lobed, usually with long hair above, but no pencil below; spots of fore wing ocellate, and all rows similar, *detecta*, *burmeisteri*, *obsolescens*, etc.
 - D. Hind wing with a slight lobe, the concavity of 1st A being about $\frac{1}{2}$ mm. deep; ocellate spots all similar and well marked, or markings wholly suffused with brown, fore tibia so far as examined, slender, considerably longer than metatarsus, with a small flat spine on its inner side; abdomen with a tawny middorsal stripe or spots, *indecisa*, etc.
 - E. Similar to group D, but fore tibia much shorter than metatarsus, with its inner claw more than half its length and very heavy, and with an additional outer spine *chelifer*
 - F. Wings rounded, the hind wing not at all lobed, spots ocellate and equal, the hind wing also with ocellate spots; abdomen with a gray or black middorsal stripe or spots on an orange ground. *suffusa*, *confusa*, etc.
 - G. Wings rounded, second and fourth rows of spots small and solid black, as in group A, or else with fore wing almost wholly suffused with black; abdomen middorsally or wholly black *atra*, *andromela*, etc.

Key to Species, Male.

- A. *Antenna plumose*.
 - 1. Fore wing rounded, with regular ocellate spots, abdomen mainly blue (Cuba)..... **albicornis*
- AA. *Antennæ shortly pectinate*—when the pectinations are only about as long as the segments, with the abdomen wholly without orange and hairy, or almost wholly orange.
 - 1. Abdomen blue, without orange, and overlaid with long white and gray hair; thorax with two or four longitudinal lines on collar, and loops on tegulæ.

*† As in the preceding papers of this series, the asterisk indicates that specimens have been examined in the collections at Ithaca, and the dagger, that the species has been studied in other American collections: the U. S. National Museum, the American Museum of Natural History, and the Carnegie Museum at Pittsburgh.

2. Hair at base of abdomen white.
 3. Collar with four fine parallel lines, tegulae with long loops, the mesothorax with four fine lines.....(*mus*)
 4. Ground of body and wings white.....†*m. mus*
 4. Ground gray or buffy.....†*m. castronis*
 3. Collar with a blue V, tegulae each with a single blue bar, and disc of thorax with a pair; palpi and frons black, legs dominantly blue *kennedyi*
 2. Hair at base of abdomen mainly gray; thorax as in *mus*, †*heterogena*
 1. Abdomen with some orange, normally mainly orange; thorax with ocellate spots, if there are any at all.
 2. Pectinations of male antennae about twice as long as width of shaft; abdomen with transverse white bands, crossing the median line; wings immaculate, or with minute ocelli...**eridanus*
 2. Pectinations about as long as width of shaft; abdomen with blue or white subdorsal spots, or largely blue; ocelli on fore wings usually well-marked, and of normal size **icasia*
- AAA. *Antennae markedly serrate, the serrations normally about half as long as width of shaft, and connected across ventrally; when somewhat longer, the abdomen blue, with orange middorsal spots, and concealed incisural lines.*
1. Thorax with solid blue spots, at least on the metathorax, and usually with two pairs on the disc also; a complete, black pleural line on the thorax under the wing; apical part of fore wing almost invariably transparent.
 2. Pectinations as seen from above as long as width of shaft; ocellate spots on wings small and well-separated; not obviously blue, front more or less white below.. . . . †*bolivar*
 2. Pectinations half as long as width of shaft.
 3. Markings of fore wing brilliant blue, heavy, the ocellate ones usually white-filled and well separated; extreme base of fore wing normally white, except for a blue spot on middle basal sclerite; ocellate spots small, the ones on collar usually covering less than half its area. . . (*scribonia*)
 4. Fore wing with some ocellate spots, especially the postmedial ones in cells Cu₁ and Cu₂, or with apex translucent and spots obscure; abdomen with dorsal orange markings conspicuous **s. scribonia*
 4. Spots solid blue, except perhaps the postmedial one on inner margin; abdomen practically solid blue above, ... *s. quitensis*
 4. Fore wing with all spots ocellate and finely outlined.. . . . †*s. columbina*
 3. Markings black, slender, enclosing darker areas, the ocelli larger, and the pair on collar covering most of the collar; fore wing with confused basal markings before the usual antemedial series (*ocularia*)
 4. Ocelli very large, flattened against the veins, and squarish, filled with pearl gray.....†*o. ocularia*
 4. Ocelli moderate, a large proportion nearly circular, filled with cream color.....†*o. robusta*
- AAAA. *Antennae simple, sometimes slightly serrate toward apex and fasciculate in forms with rounded hind wings.*
- B. *Fore wing with second and fourth rows of spots small and solid black, the alternate rows normally also black, or else suffused with black.*
 - C. *Anal angle of hind wing lobed, usually strongly.*
 1. Mesothorax and scutellum each with a pair of black spots, which may be partially fused, but show at least some trace of a pale median line; fore wing with postmedial spot in cell M₂ located near its middle, and strongly oblique down and out.

2. Fore wing white, the dark spots on both thorax and fore wing small and well spaced *persola* (♂ not seen)
 2. Fore wing with cream ground, reduced to a net of lines by the greatly extended black markings, the thorax also mainly black †*cotyora*
 1. Mesothorax with a more or less completely separated pair of black spots, the scutellum with a single rounded spot; postmedial spot in cell M₂, when present, not strongly oblique, and located close beyond end of cell.
 2. Thorax with small rounded black spots, covering less than half its surface; hind wing largely yellow, with short anal lobes; veins of fore wing not yellow (*leucarctioides*)
 3. Ground pure white †*leucarctioides*
 3. Ground of both wings cream ab. *tenella*
 2. Thorax with large bar-like spots on tegulae and disc; veins of fore wing yellow; hind wing with moderate to large lobe, transparent yellow, with more or less fuscous suffusion.
 3. Lobe half as long as width of hind wing, broadly tipped with black; hind wing typically much shaded with fuscous *flæta*
 3. Lobe a third to a quarter as long as width of hind wing, with a small black dot at its tip (*praeclara*)
 4. Ground of fore wing pure white †*p. praeclara*
 4. Ground pale yellow †*p. theophila*
 2. Fore wing without yellow veins, hind wing mostly white, black markings of thorax extensive †*magdalenæ*
 3. Antemedial and postmedial series of dots somewhat interrupted †typical
 3. Ante- and postmedial series of dots complete and strong, ... v. *steinbachi*
 1. Mesothorax and scutellum each with a single middorsal spot, or thorax with a continuous middorsal band.
 2. Ground of fore wing yellowish, much less extensive than the black markings (*ochreator*)
 3. Transverse bands of the fore wing centered with bright yellow lines, the veins deep yellow †*o. euripides*
 3. Fore wing with faintly yellower veins only †*o. ochreator*
 2. Ground of both wings white, the fore wing with ground more extensive than markings †*brasiliensis*
- CC. *Hind wing rounded.*
1. Terminal half of abdomen yellow with black dorsal dots; fore wing mostly black, hind wing blackish. †*andromela*
 1. Abdomen black to apex, with the usual yellow side-stripes. (*atra*)
 2. Hind wing mainly blackish.
 3. Forewing mostly black †*a. atra*¹ (*eminens*)
 3. Fore wing about half black †*a. extrema* (*chilensis*)
 2. Hind wing mainly white.
 3. Markings with distinctly darker edging, the second and fourth rows only a little smaller than the third †*obtecta*
 3. Markings of perfectly even brown-black, the second and fourth rows of small spots, the third on the contrary forming a solid black band †*a. amulaensis*
- BB. *Fore wing with at least the more basal spots ocellate (or fused into dark-bordered bands), the second and fourth rows like the others.*
- C. *Hind wing with a strong anal lobe, with a groove containing a hair-pencil on the under side.*
1. Abdomen pink, with transverse black stripes †*nigriplaga*
 1. Abdomen orange and black, without pink †*orsa*

¹The very brief description of *amula* Strand (*amulaensis* ab. of Hampson) gives no characters to distinguish it from *atra*.

CC. *Hind wing with a moderate anal lobe; with a mass of long hair above, sometimes making a pencil, but no groove or pencil below.*

1. Ground of abdomen scarlet, with blue-black subdorsal spots; black pleural stripe of thorax strong on mesothorax of specimens seen, but not continued on metathorax. †**burmeisteri**
1. Ground of abdomen orange or blue.
 2. Abdomen with the middorsal region dark (blue or gray) but with addorsal orange spots or bands; pleural stripe continuous (*detecta*)
 3. Abdomen with orange stripes at least as broad as the gray ones, the middorsal stripe sharply defined ***d. dorsata**
 3. Abdomen black, with small subdorsal orange stripes, extending about three segments.
 4. Smaller, subterminal ocelli of fore wing well-marked,
 4. Larger, a vague subterminal gray shade **d. detecta**
 4. Larger, a vague subterminal gray shade **d. dognini**
 3. Abdomen with two pairs of small orange spots only **d. detectiva**
2. Abdomen with orange dorsal marking when present best developed at the middorsal line.
 3. Fore wing with continuous, dark-outlined gray bands, not at all interrupted by the veins (rather obscure on account of the translucence of the wings); abdomen almost wholly blue. †**gaujoni**
 3. Fore wing with ocellate spots between the veins.
 4. Abdomen with orange only on sides, none whatever dorsally; fore wing with spots olive-filled; thorax with black pleural stripe †**jaguarina**
 4. Abdomen with some orange middorsally at least, thorax with black stripe weaker or absent; spots of fore wing rarely olive-filled.
 5. Large (70 mm.), robust, apex transparent, abdomen normally striped transversely with gray, rarely blue †**peruvensis**
 5. Smaller; apical part of fore wing with pattern; abdomen always powdery gray and orange, never blue.
 6. Expanse about 55 mm. Hind wing typically with a double spot at end of cell and a subterminal spot near anal angle (cells Cu₁ and Cu₂) †**ganglio**
 6. Smaller, hind wing at most with a vague shade along fold.
 7. Pattern on abdomen dorsally irregular.
 8. Ground buffy, the shade on fold heavy, ... †**obsolescens**
 8. Ground deep buff, some of the ocelli contrastingly paler. **testacea**
 8. Ground practically white, the hind wing with a slight gray shade at anal angle only †**cretacea**
 7. Abdomen with a continuous middorsal orange stripe with no tendency to be broken into separate spots or transverse bands. †**kinkelini**

CCC. *Anal lobe of hind wing slight ($\frac{1}{2}$ mm. deep) or none.*

1. Abdomen with middorsal region of the darker (gray) color, flanked by tawny or orange.
2. Ground white, with contrasting brown spots. **oslari**
2. Ground not white, when very pale with the filling of the ocelli hardly darker.

3. Ground of fore wing cream to light buff; dorsum of abdomen with small black spots †*confusa*
3. Ground of fore wing gray; abdomen with transverse gray bars †*suffusa*
1. Abdomen with a series of middorsal orange spots, the addorsal region dark.
2. Ground pure white.
 3. Spots very large and partly confluent, leaving narrow streaks of the white ground..... *melanoleuca*
 3. Spots small and wholly separated; fore tibia solid fuscous. †*obtecta*
2. Ground gray or brown; fore tibia with a black pattern.
 3. Fore tibia short, with a claw more than half as long as itself **chellifer*
 3. Fore tibia longer than metatarsus. with a weak claw.
 4. Ocellate spots slightly grayer than ground, and defined by white outlines only †*biscripta*
 4. Ocelli dark, and outlined with dark as well as pale, ... **indecisa*
1. Dorsum of abdomen and fore wings brown, without obvious markings *anomala*

Key to Species, Female.

1. Fore wing with second and fourth series of spots solid black, and much smaller than first, third and fifth 2
1. Fore wing with numerous black spots, not arranged in series of unequal size 5
1. Fore wing otherwise marked, almost always with ocellate spots 6
2. Hind wing mainly black or dark gray 3
2. Hind wing ochre yellow with black spots †*ochreator*²
2. Hind wing mainly white 4
3. Thorax with paired spots, sometimes partly fused, but showing traces of the pale dividing line, on both mesothorax and scutellum; postmedial spot in cell M₂ of fore wing half-way out to outer margin and strongly oblique †*cotyora*
3. Mesothorax with paired spots, scutellum with a single rounded spot; postmedial bar in cell M₂ close beyond end of cell, ... †*laeta*, *leucarctioides*, *magdalenae*, *praeclara*³
3. Thorax with both spots unpaired, or with a longitudinal band; post-medial spot as in the preceding category †*brasiliensis*
4. Third (median) series of spots in fore wing represented by a broad and solid black band †*amulaensis*
4. Third series of spots represented by a band cut by contrasting yellow veins..... †*andromela*
4. Third series of spots separated by white veins; hind wing with spots small, or else suffused with fuscous..... †*extrema*
5. Hind wing and abdomen yellow †*persola*
5. Hind wing white, abdomen dorsally blue *scribonia* *quitensis*
6. Abdomen wholly blue, white and gray, without orange even on sides 7
6. Abdomen at least with orange lateral stripes..... 9
7. Base of abdomen with mostly smoky hair; larger and coarser..... †*heterogena*
7. Hair at base of abdomen mainly white; smaller (*mus*)..... 8
8. Ground practically white, with white-filled ocelli; hind wing mainly white..... †*m. mus*

²The female of *euripides* is unknown; it is likely to be separable in the same way as the male.

³There are females in the U. S. National Museum associated with these various male forms, but I am unable to distinguish them.

8. Fore wing cream or buff, the ocelli darker-filled; hind wing with fuscous area at least entering cell, the wing often mainly fuscous.....†*m. castronis*
9. Abdomen with middorsum solid blackish, flanked by addorsal orange markings..... 10
9. Abdomen with dorsal orange markings, when present at all, best developed on the middorsal line, frequently with middorsal segmental spots..... 11
10. Ground of fore wing light buff, dorsal spots of abdomen very small. .†*confusa*
10. Ground of fore wing gray; dorsal spots conspicuous, frequently developed as transverse bars.....**suffusa*⁴
11. Ground of fore wing gray or smoky; abdomen mainly gray or blue..... 12
11. Ground of fore wing white, frequently tinted with buff or pinkish, somewhat darker in some specimens of *nigriplaga*, which have the abdomen transversely striped with pink and black..... 14
12. Abdomen wholly blue above, with lateral orange stripes, only; fore wing banded, not ocellate.....†*gaujoni*
12. Abdomen spotted dorsally with orange..... 13
13. Spots of fore wing outlined in black and white; fore tibia banded.....**indecisa*
13. Spots of fore wing outlined in black and bright yellow; fore tibia plain blackish.....†*tobecta* (*flavomaculata*)
13. Spots of fore wing outlined in white only.....*albascripta* (supposition)
14. Abdomen pink or scarlet..... 15
14. Abdomen with more or less orange, not red..... 16
15. Abdomen with transverse dorsal stripes; ocelli of fore wing heavily ringed with black, and frequently dark- or pale-filled.....†*nigriplaga*
15. Abdomen with subdorsal spots; ocelli filled with darker gray and frequently large or even confluent.....†*burmeisteri*
16. Abdomen orange, with the subdorsal markings largely white, normally outlined in blue..... 17
16. Abdomen dominantly blue, or subdorsally spotted with blue..... 18
17. Abdomen with transverse dorsal white stripes crossing the middle line; fore wing immaculate or with a few small ocelli.....†*teridanus*
17. Abdomen with subdorsal white bars, the fore wing frequently with a regular pattern of ocelli.....**icasia*⁵
18. Abdomen with a continuous orange dorsal stripe on middle segments; body more or less gray.....*aramis* (? ♀ *kinkelini*)
18. Abdomen otherwise marked, frequently with a series of middorsal orange spots..... 19
19. Hind wing and filling of ocelli of fore wing white..... 20
19. Hind wing more or less shaded with fuscous, the centers of the ocelli of fore wing markedly darkened..... 25
20. A black line on side of thorax, extending back from the eye below the base of the wings..... 21
20. No such stripe, the thorax at most with a few blackish hairs behind the eye..... 22
21. Abdomen orange with blue spots.....*orsa decora*
21. Abdomen mainly blue.....**scribonia*, †*l. mexicana*
22. Hind wing with numerous gray-filled and sometimes somewhat suffused, ocelli (Cuba).....**albicornis*
22. Hind wing with slight markings or none (Mainland)..... 23
23. Abdomen blue with small orange spots.....†*tobsolescens*
23. Abdomen largely orange, with dark transverse bands..... 24

⁴The female of *detecta*, which is unknown to me, will presumably run here; it will probably be larger, with more visibly lobed hind wings. The female credited to *dogmini* appears to me very improbable, as, so far as we know, females in this genus always have the black markings less extensive than the males. It may possibly be the true female of *jaguarina*.

⁵This character will occasionally fail, but I know of no better one; the antennal difference in the male shows that these are really distinct species.

- | | | |
|-----|---|-------------------------|
| 24. | Fore wing, and especially filling of ocelli, more or less buff | testacea |
| 24. | Fore wing nearly white; smaller | †cretacea |
| 25. | Ocelli very large and squarish, being more or less flattened against the veins, or even partly fusing | *ocularia |
| 25. | Ocelli normal, usually well separated ⁶ | 26 |
| 26. | Abdomen wholly blackish, even the incisural folds | jaguarina (supposition) |
| 26. | Abdomen with at least middorsal orange spots | *orsa |

DISCUSSION.

It will be noted that the most serious divergences from Hampson's arrangement are due to the recognition of pectinate antennæ or of the lobe and pencil of the hind wing in several forms where he did not note any secondary sexual characters. The groupings into races are tentative, but I think correct in the case of the two protean species *orsa* and *icasia*. I have placed several of Oberthür's names tentatively, since he gives no hint of the structural characters. The stripe on the side of the thorax, from the eye to the base of the abdomen, just below the articulation of the wing, seems to be a good character, but breaks down in the case of *E. icasia*, where it may be present or absent in otherwise similar specimens from the same region. Generally it seems constant for species, and even groups of species.

E. albicornis Grote. As I noted some time ago (Bull. Am. Mus. Nat. Hist. xxxvii, 340), this species stands in contrast to all the rest of the genus in the broadly pectinate male antennæ. The appearance is also unique, as shown well by Grote's original figure, (Proc. Ent. Soc. Phil. 1865, pl. 4, Fig. 4), and the species may be one of the numerous Antillean relict-forms. It is in the National Museum, the American Museum, and at Cornell, in all three cases from the Schaus collection. The species in spite of its different appearance shows most of the characters of *icasia* and *eridanus*, and I am not sure the key characters will always work for the female. In all three the face is white below, with or without a black bar.

E. eridanus Cr. Cramer's figure is of a female, in spite of Seitz's note that "only males seem to be known hitherto." Oberthür figures a male from Colombia under this name, and both Hampson and Seitz seem to have described merely from

⁶Light specimens of *orsa* may lose the gray on the hind wing, and then look much like *icasia*, but apparently in that case they always have light faces, and plainly fuscous-centered thoracic markings.

Oberthür's specimen, which I take to be an immaculate specimen of *icasia muzina*, especially as we have a similar immaculate specimen of *i. icasia* from Porto Rico. On the other hand there is a species in Guiana (Cramer's type locality) which characteristically has the white stripes across the abdomen, and is undoubtedly Cramer's species. As noted in the synopses it has significantly broader antennæ than any of the forms of *icasia*. The National Museum has a maculate specimen, and it shows minute ocelli, as in Hubner's figure of *eridane*. The name *eridane* is obviously only a variant spelling of *eridanus*, and has therefore no standing.

E. kennedyi Roth. Unknown to me. The male should be easily recognized by the characters given by Hampson and repeated in my key. The species of this group are so strongly dimorphic sexually that there is no guarantee that the same characters will appear in the female.

All the species of this group are distinguished by the fact that the collar has stripes its whole height, instead of the ocelli or loops of the rest of the genus. The complete absence of orange or red on the body also seems characteristic.

E. mus Obt. I can recognize only two races of this species in the material I have seen: typical *mus* (in the National Museum from Bolivia) and *m. castronis* Strand (*brasiliensis* Roth., not Obt.), from Castro, Paraná, Brazil. If the gray abdominal hair is of specific value, *heterogena* will be a distinct species, and is distinguishable in both sexes; but it is hardly more distinct from *castronis* than *castronis* is from typical *mus*. I am inclined to think the antennæ are a little broader in *heterogena*.

E. heterogena Obt. In the typical form the front is white, in *pellucida* black, but the character appears only of aberrational value in most species of this genus. *Contexta* is, I judge, the normal female.

E. icasia Cr. This name represents the Antillean form of a variable species or series of representative species scattered over a large part of Central and South America. There is a great deal of variation in most details of pattern, and even some in the wing-form of the female, but the whole series seems to intergrade completely, and even in the typical localities of the various forms there is usually a wide range of variation. The

most distinct form is *icasia* itself. If we consider only typical specimens of the various local forms, they may perhaps be separated as follows, but the exceptions are about as common as the normal forms, and in Venezuela there appears to be a complete blending of all.

(a). **E. i. icasia.** Collar white, without ocellate markings, which are usually conspicuous on the rest of the thorax and fore wing. Abdomen bright orange, the subdorsal spots normally small and well-contrasted, typically blue-black, but sometimes largely white, even in the male; in the female as usual, white. Markings tend to be light but clean-cut. Female with anal lobe well marked and pointed, the wings frequently immaculate or nearly so. Antilles.

Guadulpensis is an aberration with a broken dark post-medial line on the hind wing.

(b). **E. i. trinitatis** Roth. Pale, tending to become immaculate, the ocelli usually fine, but distinct, and present on collar as well as thorax and wings; the abdominal spots typically with some white in male, and wholly white in female; female wings long, and anal lobe of hind wing pointed, as in *i. icasia*. This is the normal mainland form of the species, and I cannot subdivide it, though Mexican and Peruvian specimens each seem to have a slightly different appearance. There is complete intergradation between this form and *muzina*, but as the latter seems locally constant in part of Colombia, and has a distinctly different wing-form in the female at least, I am holding it as a good race. I found the larvæ of *trinitatis* somewhat abundant in Lima, Peru, where they do some damage to shade-trees in the city; they are not noticeably different from *scribonia* save in their smaller size.

Oberthür has described *abscondens*, *garzoni*, *yukatanensis* and *xanthonota* in this group. *Yukatanensis* is transitional to *mexicana*, the other three names fairly represent the range of normal variation in the female. Of the other female names, *abscondens* has a complete series of small submarginal ocelli on the hind wing, while in *garzoni* and *xanthonota* the ocelli are large, and there is also some postmedial dark shading toward the inner margin.

Albicollis from Brazil, distinguished by the absence of ocelli on the collar, as in typical *icasia*, combined with the

white abdominal spots of *trinitatis*, may be a distinct form, but it is unknown to me, and a single specimen is not enough to found a race on in such a variable species as this.

(c). **E. i. muzina** Obt. Markings complete and well contrasted, the hind wings of the female with the anal angle broadly rounded, and less prominent than in the other forms on account of the generally broader wings. In the original figure of the male, and the dwarf figured as *thimei* Obt., there are no rings on the collar, but they are generally present; *depauperata* Obt. is the female of this form, and represents a specimen with almost wholly white hind wings.

(d). **E. i. mexicana** Obt. This appears to be a partially racial form in Mexico and Central America. In it the abdomen is mostly blue, but at least with orange mid-dorsal segmental spots. The National Museum has a complete series of intergrades from it through forms with large triangular blue spots on orange (*yukatanensis*) to specimens not unlike normal *trinitatis*. The blue body strongly suggests a light phase of *scribonia*, but the male structure is quite distinct. Still it is not unlikely that Mexican specimens of *scribonia* may be mixed with this in some collections.

E. bolivar Obt. This species seems like a connecting link between *scribonia* and *icasia*. On final analysis the only superficial character that seems to separate it from *icasia* (form *mexicana*) is the presence of solid blue spots instead of dull black ocelli on the back of the thorax. The antennæ are almost as wide as in *icasia*, but the appearance really suggests a nearer relationship to *scribonia*. I have not recognized the female, which will presumably have ocelli on the metathorax, and be hardly distinguishable from *mexicana*.

E. scribonia Stoll. The "Great Leopard Moth" of North America has been known for a century under this name. Hampson thought he recognized in it Fabricius' *deflorata*, but his other identifications in the genus are so often wrong that it seems safer to go back to the old name, especially as Fabricius plainly speaks of a moth with *four* black spots on the thorax instead of the twelve spots or ocelli of *scribonia*. Also Fabricius speaks of the wings as merely spotted, while it is very rare to find a specimen of *scribonia* without some conspicuous ocelli. It would not be impossible that Fabricius had *Hy-*

phantria cunea! The North American form of this species is well known. Specimens from south of the U. S. line seem very scarce, though I have seen a single specimen in the American Museum which appears to represent v. *columbina* Obt.; it comes from Paraguay. So far as I know, all the forms have the bright blue front and fore coxæ, without the variation to barred and gray-marked forms usual in the genus. The two racial forms known from South America are opposite extremes, *quitensis* having the ocelli all replaced by solid blue spots, while in *columbina* they are as slender as in other species of the genus. Oberthür's aberration *confluens* has the second and third rows of ocelli fused; it belongs to typical *scribonia* and not to *quitensis* as Hampson states. *Denndata* is merely based on specimens with the apex of the fore wing transparent; it is really the normal male.

E. ocularia F. What commonly goes as *ocularia* Fabricius is a close relative and in a way a representative of *scribonia* in South America. I see no real difference in the antenna, and such characters as the front and coxæ are also the same, but the large dark-filled ocelli give it a very different appearance. *Robusta*, to judge by the types in the National Museum, is merely a slight local form, with the difference given in the key. I am not at all sure of the female characters in this series; and there may exist specimens of *peruvensis* with blue abdomen which would be practically identical with *ocularia*. The one female *peruvensis* in the National Museum has a gray abdomen like the more usual males. There also seems to exist at least one more species with simple antennæ and almost the same pattern, besides *jaguarina*, which may be distinguished in the male, and presumably the female, by the complete lack of dorsal orange even in the infolded incisures.

Next follow a group of very distinct species in which the antenna is simple, but the hind wing has a strong lobe, and the markings are wholly of black spots, without the usual ocelli. In all cases the second and fourth rows of spots are distinctly reduced in size, a character which reappears in some species of the closely related genus *Turuptiana*; but the difference in size is small in *E. persola*. There are perhaps fewer species than I have recognized, but the presence of single or paired spots on the thorax, which I have used in the key, appears to be an important character. Some forms of *læta* would also appear

identical with *præclara*, were it not for the distinct difference in the anal lobe. In fact I am completely unable to separate the females of these two species. The species of this group lack the hair-pencil on the under side, but have only a little stiff scaling, while in *orsa*, *decora* and *nigriplaga* the pencil is conspicuous. The group is an ancient one, apparently, and is one of those curious types, like *Clothilda*, which are confined to Central America and the Antilles, without making the connection through northern South America. Presumably the group is older than the present break (of sea and desert) between Cuba and Yucatan.

E. persola Msch. I have not seen the male; to judge by the female the species is unique in having three spots on the scutellum, an odd one besides the two it shares with *cotyora*. The position of the postmedial line opposite the cell shows that the connection with *cotyora* is fairly close.

E. nigriplaga Wlk. Another of the very curious series of species known only from Jamaica. It is obviously an island representative of *orsa* (*cunigunda*) of the mainland, but is very distinct in the red color of the abdomen, and the lobing of the hind wing is even stronger. On the other hand, *decora*, from the other Greater Antilles, has the anal lobe rather small, and if it were not for the well-marked hair-pencil, might not be recognized as belonging here.

E. orsa Cr. I think the lobed hind wing and general pattern leave no doubt that this is the same species that Stoll later named *cunigunda*. In Cramer's figure, which is much cruder than most of his, the fore wings have a complete pattern of ocelli. This is a rare character, but I have seen such specimens; more often the apex is more or less transparent (ab. *cunigunda* Stoll). Hampson overlooked the yellow hair-pencil on the under side of the hind wing, which is distinctive of this species and *nigriplaga* (and *decora* if distinct); and has the synonymy completely confused. Considering this character, and including the females which seem to be associated here, I believe the series includes: *orsa* Cr., *cunigunda* Stoll, *cayennensis* Obt., *decipiens* Obt., *bari* Obt., *dubiosa* Obt., *alpha* Obt., (with *orbiculata* in part), *perplexa* Schs., *abdominalis* Wlk., *proxima* Obt. and *annexa* Obt. (with the rest of *orbiculata* Obt.). These names were described from a wide range

of localities, and some of them represent more or less tangible local forms, but they intergrade as completely and are as unstable in a given locality as the forms of *E. icasia*. The following names belong to other species without the lobe and hair-pencil: *delecta* and *detectiva* Obt., *aramis* Obt., *ganglio* Obt. *Ganglio* shows a striking superficial resemblance to females of this species, but I cannot imagine how the others came to be put in the synonymy.

(a). **E. o. decora** Wlk. (*cyaneicornis* Grt., *haitensis* Obt.). A very distinct form, or possibly a representative species, isolated in the Greater Antilles. It can be distinguished by the fact that the dark markings at the end of the cell (parts of two or three confused ocelli) are shining metallic blue, contrasting with the clear black of the rest of the markings. Body orange with black spots in male, reduced to dots in the female. Face white; bar on thorax below base of wing variable; hind wing with dark shading in fold only in male, with ocellate spots in female.

(b). **E. o. orsa** Cramer. Typically with a complete pattern of black ocelli, more often (var. *cunigunda* Stoll.) with the apical half of the fore wing transparent in the male. Cayenne to Venezuela.

(c). **E. o. alpha** Obt. Hardly a tangible local form, but generally larger, the female tending to have a pale hind wing. Mexico.

(d). **E. o. perplexa** Schs. A gray postmedial band on hind wing, distinct at least on inner margin. This may turn out to be an aberration rather than a race, but seems locally constant. Costa Rica.

(e). **E. o. abdominalis** Wlk. I question if this can be held as a race, though in series there appears to be a little difference in appearance. I believe the difference given by Hampson between alpha and abdominalis is purely imaginary, perhaps due to a different setting of the hind wing. If the hind wing is not carefully spread the anal region remains folded and the hair-pencil will be completely concealed. Brazil.

Next follow a series of species which agree in not having any very distinctive sexual characters either of the wing or the antenna. They are perhaps not a homogeneous group, yet are somewhat connected by a chain of resemblances. All

have a moderate anal lobe in the male, less conspicuous in the female. The band on the side of the thorax is more stable in this group than the preceding, and seems always to be the same in a single species, and even in groups of closely related species.

E. detecta Obt. As this species I group all the forms in which there is a gray middorsal region, flanked by addorsal orange spots or bands; the amount of orange varies markedly, and I think locally, from the broad bands of the new form described below to the minute dots of var. *detectiva*. I put *dognini* here with some hesitation, as I have not seen it; the male shows the characteristic addorsal orange, but it is figured as larger than typical *detecta*, and the suffused gray subterminal band, if not a mere individual aberration, is unique in the series. The female, as figured by Hampson, shows neither the orange spots nor the subterminal band, and, as far as I can see is the proper female to go with *jaguarina* Schs., which also has the plain blue dorsum and olive-tinted ocelli. I should recognize four forms, which appear to be racial.

(a). **d. detecta** Obt. Fore wing with ocellate spots larger than the spaces between them, and gray-filled. Hind wing pure white, without obvious markings. Abdomen gray above, with two short orange stripes, setting off a median longitudinal gray stripe, which is cut only by the orange incisures (usually concealed by the shrinking of the abdomen). Para, Amazons.

(b). **d. detectiva** Obt. Paler (faded ?), the ocelli relatively smaller; hind wing with a gray anal spot, the orange on the abdomen reduced to two pair of small spots. Locality not stated.

(c). **d. dognini** Roth. Larger, the ground more or less yellowish, the ocelli showing the buffy tint of *detectiva*, but more nearly the pattern of *detecta*; the abdomen as in typical *detecta*. Southern Brazil.

(d). **d. dorsata** new race.

Fore wing as in the typical form, with ocelli large and nearly in contact, and markedly gray-tinted; dorsum of abdomen broadly orange, with a relatively narrow gray middorsal band. In the type the whole dorsum is orange, with dorsal and lateral gray stripes; in the paratypes the gray is more extensive, and the dorsal stripe is irregularly widened.

Urucum, above Corumbá, Matto Grosso, Brazil, Dec. 23, 1919, Bradley and Harris.

E. jaguarina Schs. This species is perhaps the most generalized of the group, except for an undescribed species, which differs from it mainly in having preserved the orange pattern of the abdomen. It is instantly recognizable in having no dorsal orange whatever, and almost as definitely in the light olivaceous buff tint of the filling of the ocelli, approaching *robusta* in appearance. The thorax has the lateral stripe, like the *scribonia* group, etc., but unlike *gaujoni* and *peruvensis*. I have only seen the male types, but believe that the female of "*dognini*" belongs here.

E. gaujoni Dgn. Easily distinguished by the complete lack of ocelli, which are replaced by black-edged transverse bands, conspicuous in the female, but only faintly seen on the transparent wing of the male. The lateral stripe of the thorax is absent; and the abdomen mainly black.

E. peruvensis Hamps. At first glance this species looks like a mere race of *scribonia*, especially the specimens in which the abdomen is blue. The typical ones with gray abdomen are more distinct; the antenna is simple (perhaps showing some slight serration at the apex), and the lateral stripe on the thorax is reduced to a few dark hairs behind the eye. The blue fore coxæ and front, used as a character by Hampson, fail in series, as in most species of this genus; the pink tint, also specified by Hampson, is more noticeable in *burmeisteri* and *kinkelini*, where it may be very bright. There are specimens from Paraná with the fore wing practically fully scaled, and merely a dot on the inner margin of the hind wing, which may be a race of this species.

E. ganglio Obt. This species looks startlingly like an undersized specimen of *orsa*, but entirely lacks the secondary sexual characters. Of the two specimens I have seen, one has lost the marginal marking of the hind wing, and the other the mark at the end of the cell. The abdominal pattern, with a tendency to cut off orange subdorsal dots, reappears in *orsa* forms.

In the following species the thorax is unlike most *Ecpantherias* in having a simple fine black loop on each tegula, while in general the loop is constricted, or divided into two ocelli; on the other hand, unlike the *mus* group, the collar has regular ocelli.

E. obsolescens Hmps. If this is correctly identified in the U. S. National Museum, Hampson's figure of the male was based on a deformed specimen with exaggerated anal lobe. Otherwise they agree.

E. testacea Roth. I have seen nothing like this, which must be extremely close to *obsolescens*.

E. cretacea Dgn. Quite a distinct species, and the smallest and most lightly marked of the normal group. The relationship is plainly to *obsolescens*, and a little more distantly to *peruvensis*.

E. burmeisteri Roth. The small size and rather large gray-filled ocelli which show a tendency to fuse, give this species quite a marked resemblance to *detecta* and *aramis*; but the regular series of middorsal salmon (orange) spots is immediately distinctive, *aramis* having a continuous stripe and *detecta* a gray median region. One specimen in the National Museum (somewhat suffused in pattern) has the abdomen orange instead of salmon, and may be either an aberration or a faded specimen. The thoracic spots are less noticeably dark filled than in *aramis*, with which Dognin confused the species.

E. kinkelini Burm. (*aramis* Obt.). Easily distinguished by the *continuous* middorsal stripe, which is short in *kinkelini*, but reaches the end of the abdomen in *aramis*. It seems still uncertain if these are local forms or sexes.

Group indecisa. In this group the anal lobing of the hind wing nearly disappears but not quite. Sexual dimorphism in coloring seems common, and in *obtecta* is extreme. In the female the abdomen seems always to have a conspicuous series of middorsal orange spots, which are less a feature of the male. There is a tendency in all the species to develop a slight claw on the fore tibia, which becomes very large in the species described below. I have not seen *anomala*, but it seems to belong here. *Obtecta* is distinguished from most of the rest of the genus by the immaculate dark fore tibia.

E. chelifera new species.

Superficially similar to *indecisa*. Fore wing darker (male), the gray filling of the ocelli less contrasting; hind wing immaculate (type) or with some obscurely ocellate terminal spots at apex (Buenos Aires), or with an anal spot, and the fringe black from Cu_2 to 2d A. Costa of hind wing beneath bright ochre yellow, contrasting (as in the female

of *obtecta*, but unlike *indecisa*). Fore tibia much less than half as long as tarsus, dark gray, with a lighter gray band across its middle, edged with cream white lines and broad black bars, unlike the simpler cream and black barring of *indecisa*. A massive inner claw, a third as long as the tibia, and a smaller outer claw.

Type male from Tintina, Santiago d'Estero, Argentina, Feb. 21, 1920, and paratype from Buenos Aires, received as *E. indecisa*. Also a paratype from Tucuman (P. Girard, Dognin coll.) in the U. S. National Museum. It is possible this may be the form noted as ab. 1 of *indecisa* by Hampson, which Strand christened *indecisana*, apparently without seeing a single specimen; but *indecisa* does in fact vary considerably in ground color, and Hampson makes no note of the characteristic structure or color of the under side. Mr. Tams of the British Museum writes me that Hampson did not label his unnamed aberrations, and that therefore the "type" of *indecisana* is not to be identified. The leg of this species is obviously fossorial, and leads one to suppose there is something special in the life history.

E. oblecta Dgn. Sexual dimorphism in this species is striking, but both sexes have the plain brown fore tibia, unlike *indecisa* and *chelifer*. I accept the identification from Dr. Schaus, who has based it on the hermaphrodite collected by Jorgensen (Revista Soc. Cien. Paraguay, i, 90.) of which there is a colored figure in the National Museum.

Group atra. I will not pretend to say how many real species there are in this group, but suspect there are less than the four I list. All are Central American, and I have only seen material in the National Museum. They are representatives of the *lata* group, also mainly from Central America, but wholly lack the anal lobe; the presence of middorsal abdominal black spots in the only case where the black is so restricted as to make it possible to tell (male *andromela*) indicates a connection with *suffusa*, rather than *oblecta*, which some of the males resemble at first glance.

Group suffusa. *Suffusa* and *confusa* seem to intergrade in the U. S. National Museum, though typical specimens are different enough. The only other species which may belong here is *oslari*, which I have not seen.

LIST OF SPECIES, WITH CITATION OF THE MOST IMPORTANT
PUBLISHED FIGURES.

Obt.—Oberthür: Etudes d'Entomologie, fascicule vi. .

H—Hampson: Catalogue of the Lepidoptera Phalaenæ, vol. iii.

Hs—Hampson's Catalogue, Supplement, vol. ii.

S—Seitz: Macrolepidoptera of the World, vol. vi. (The figures on each line of the plates are numbered from the left).

Group A.

1. **albicornis* Grote, Proc. Ent. Soc. Phil., v. 4: 4.

Group B.

2. **eridanus* Cramer, 68 G.
syn. (ab.?) *eridane* Hbn. Samml. Exot. Schm. i, pl. 191 (Kirby's numbering).
3. *icasia* Cramer 181 E; S 41 a5 ♂, b1 ♀.
a. **i. icasia* Cr. (West Indies).
syn. *lantane* F.
obliterata Wlk. (Nevis).
simplex Wlk. (Nevis).
eridanus Seitz, pp. 473, nec. Cr.
ab. ♂ *guadulpensis* Obt. 13:2 (Guadeloupe).
- b. **i. trinitatis* Rothschild (Trinidad to Peru).
- c. **i. muzina* Obt. 12: 4; S 41 a2 (poor of ♂), 3 ♀, (Colombia, etc.).
eridanus Obt. 12: 1; S 41 b3, nec Cr.
? *caudata* Wlk. (has priority if correct).
♂ *thimei* Obt. 12: 6 (dwarf).
♀ *depauperata* Obt. 12: 8.
♀ *abscondens* Obt. 12: 7.
♀ *garzoni* Obt. 13: 3.
♀ *xanthonota* Obt. 13:6.
- d. †*i. mexicana* Obt. 15: 1♂ (3 ♀?), (Mexico, U. S.?).
ab. trans. †*yukatanensis* Obt. 13: 4.
- e. *i. albicollis* Obt. 12: 5 (? if distinct, not seen), (Brazil).
4. *mus* Obt. 16: 1; S 41 b4.
a. †*m. mus* Obt.
♀ *bahiaensis* Obt. 16: 5; S 40 h4.
♀ *boisduwali* Obt. 16: 6.
- b. †*m. castronis* Strand.
brasiliensis (*braziliensis*) Roth., nec Obt. Hs 62: 13, 14.
5. †*heterogena* Obt. 15: 2; S 40 h3 ♀.
pellucida Schs. Am. Lep. 3: 11, 12.
♀ *contexta* Obt. 16: 2.
6. *kennedyi* Rothschild Hs 63: 1 ♂.

Group C.

7. †*bolivar* Obt. 13: 1.
8. *scribonia* Stoll, Cr's Suppl. 41: 3; Hbn. 403; Obt. 17: 5; etc.
a. **s. scribonia* Stoll.
ocularia auct., possibly of F.
oculatissima A. & S. Pl. 69.
deflorata Hamp., nec F. S 40 g1 ♂, 2 ♀.
cunegunda Beauv., (not *cunigunda* Stoll).
chryseis Oliv.
ab. ♂ *denudata* Slosson.
ab. ♂ *confluens* Obt. 17: 3; S 40 g3 (*trans.).
- b. †*s. columbina* Obt. 16: 3 ♂ (4, 7 ♀?).
- c. *s. quitensis* Obt. 17: 1, 2; S 40 f5 ♀.

9. *ocularia* auct. (F.?) S 40 g5 ♂, 4 ♀.
 - a. **o. ocularia* auct.
cyaneator Wlk.
? *columbina* Obt. 16: 4, 7 ♀.
ab. *distans* Obt. 17: 6 (possibly to form *robusta*).
 - b. †*o. robusta* Dognin Lep. Loja 4: 10 ♂.

Group D.

10. †*persola* Moschler, S 41 c3 ♀.
11. †*cotyora* Druce, *Biologia Centrali-Americana* 10: 4, 5; S 40 f2 (pale male), 3 ♀.
12. †*leucarctioides* Grote and Robinson, S 40 e5 ♂, 6 ♀.
 - ab. *tenella* H. Edwards.
trebula Druce.
13. †*laeta* Walker, H p. 369; S 40 e2 ♂.
14. †*præclara* Obt. 19: 1; S 40 e3 ♂.
 - ab. *theophila* Dognin.
15. †*brasiliensis* Oberthur 19: 2, 3, 6; S 40 e4 ♂.
 - brasiliensis* Hamp.
? *nigriloba* Hulstaert, Ann. Soc. Ent. Belge, lxiv, 106, 1924 (Petropolis, Rio, Brazil).
16. †*magdalenæ* Obt. 18: 5, 8; S 40 e1 ♂, d6 ♀.
 - ab. *steinbachi* Roth.
17. *ochreator* Felder 101: 2; S 40 f1 ♀.
 - a. †*o. ochreator* Fld.
 - b. †*o. euripides* Dyar, Hs 63: 2; S 67 e4 (as *eurypides*).

Group E.

18. †*nigriplaga* Walker, H 47: 13; S 41 b5.
19. *orsa* Cramer 143: F.
 - a. *o. orsa* Cr. (Northern South America).
cayennensis Obt. 14: 1 ♂, 3 ♀.
decepiens Obt. 15: 6 ♀.
bari Obt. 14: 5 ♀; S 40 il.
dubiosa Obt. 14: 6 ♀.
*normal male *cunigunda* Stoll in Cr. 344 D, E; S 40 h2.
 - b. †*o. alpha* Obt. 14: 2 ♂; S 40 i5 (Mexico and Central America).
orbiculata Dr. nec. Obt.
decora Dr. nec. Wlk.
 - c. †*o. perplexa* Schs. Hs. 63: 3; S 67 e6 (Costa Rica).
 - d. **o. abdominalis* Walker, S 40 i2 ♂ (Brazil).
orbiculata Obt. 14: 7 ♀.
proxima Obt. 15: 9 ♀.
annexa Obt. 14: 4 ♂.
 - e. †*o. decora* Walker S 40 h5 ♂, 6 ♀.
cyaneicornis Grote.
haitensis Obt. 15: 5, 7.

Group F.

20. *detecta* Oberthur 15: 8.
 - a. . d. *detecta* Obt. (Para).
 - b. d. *detectiva* Obt. 17: 4; S 40 i3 (no locality).
 - c. d. *dognini* Roth. Hs 63: 5 ♂ (not 6); S 67 f3 (S. Brazil).
 - d. **d. dorsata* new race (Matto Grosso).
21. †*jaguarina* Schaus, Ins. Ins. Men. 1921, p. 170.
? *dognini* Roth. (female, not male), Hs 63: 6; S 67 f4.
22. †*gaujoni* Dognin Lep. Loja 4: 11, 12.
? *oculatissima* var. Obt. (from Brazil).
23. †*peruvensis* Hampson, H 51: 10; S 41 b2 ♂.
24. †*ganglio* Obt. 13: 5.

25. †obsolescens Hampson, Hs 63: 9, 10.
 26. †testacea Roth., Hs 63: 7, 8.
 27. †cretacea Dognin, Hs 63: 11, 12; S 67 f1 ♂, 2 ♀.
 28. †burmeisteri Roth. Nov. Zool. xviii 3: 23, 24; S 41 c2 ♂, 1 ♀.
 29. †kinkelini Burmeister, Obt. 18: 1, 6; S 41 a4.
 a. .k. kinkelini Burm. (Argentine).
 b. k. aramis Obt. 18: 2, 3; S 40 i4, (Brazil).

Group G.

30. *indecisa Walker, Obt. 18: 4, 7; S 40 d1 ♂, 2 ♀.
 degenera Wlk.
 annulifascia Wlk.
 ab. indecisana Strand.
 31. †obtecta Dognin, S 67 c7 ♂.
 ♀ flavopunctata Schs.
 ? ab. ♂ melanoleuca Roth. Nov. Zool. xviii 3: 17; S 41 a1.
 32. †albiscripta Druce, H 47: 6; S 40 d3.
 33. anomala Burmeister.

Group H.

34. *chelifer, new species.
 indecisa auct. in part (possibly S 40 d1 ♂, 2 ♀),
 possibly indecisana Strand.

Group I.

35. †confusa Druce, Biologia 75: 7.
 36. *suffusa Schaus, Biologia 75: 11; S 40 d4 ♂, 5 ♀. (possibly a var. of confusa).
 37. oslari Roth. Nov. Zool. xviii 3: 29; S 41 b6.
 ? semiclara Stretch.

Group J.

38. †amulaensis Dr. Biologia 75: 4; S 67 g1 ♂, f5 ♀.
 ab. amula Strand.
 39. †extrema Walker, S 40 f4.
 chilensis Obt. 20: 5.
 40. †andromela Dyar, Hs 63: 13, 14; S 40 c6 ♂.
 41. †atra Obt. 15: 4; S 40 c7 ♂.
 ab. eminens H. Edwards.

THE COMPARATIVE MORPHOLOGY OF THE SPIRACLES OF TWO SPECIES OF WEEVILS.

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The subjects of this study were the granary weevil (*Sitophilus granarius* Linn.) and the corn billbug (*Sphenophorus maidis* Chitt.).

Although the granary weevil is well known as a mill pest, the morphology of the species has not been extensively studied. This has probably been partly due to the fact that the adult insect is only 2 to 3 mm. in length. The corn billbug is from 2 to 3 cm. in length.

Both species have five pairs of abdominal spiracles lying in the pleural coria just above the hard sternum. It was this group of spiracles that was studied. The granary weevil appears to have a pair of thoracic spiracles, but these are very difficult to isolate.

A special technique was required for the dissection of the granary weevil. The beetles were mounted in a paraffin block and dissected under 50% alcohol with the aid of a binocular magnifier. The entire abdominal dorsum was removed, passed through graded alcohols, and mounted on a slide. In some cases the tissues were stained with Ehrlich's haematoxylin; in others the soft parts were removed with sodium hydroxide. Sections were also made of the whole abdomen. These were cut 30 μ thick from paraffin and stained with iron-haematoxylin and lichtgrun.

The spiracles of the billbug could be easily dissected out under the binocular. Some were studied under the magnifier; others were mounted on slides and examined microscopically.

By referring to Figure 1, one can study the characters of spiracular structure in the granary weevil. Beyond the spiracle proper (S) is a chamber (A), leading to a chitinous bow (B). Just beyond this bow the trachea is constricted somewhat, but at once widens to form a kind of vestibule (V). There are two tracheal trunks (T and T₁) communicating with the vestibule. No muscles are attached to any part of this apparatus.

No evidence of spiracular closing could be found in either living or dead specimens.

The spiracles of the billbug differ strikingly from those of the granary weevil. In addition to the heart-shaped spiracular opening, there is a true atrium continuous with a pair of triangular chitinous plates (B and B₁; Figures 2, 3, and 4). Between these plates is a slit (O) communicating with the large air chambers so conspicuous in the body of this species. This slit, normally closed, is opened by the contraction of a band of

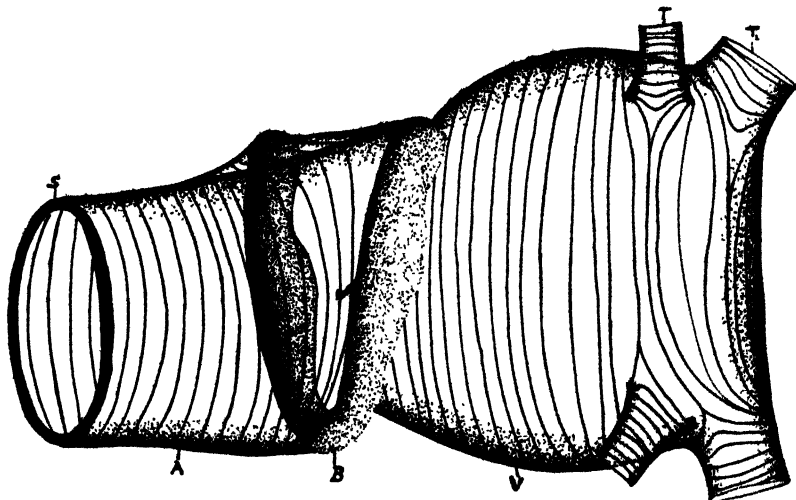


Fig 1

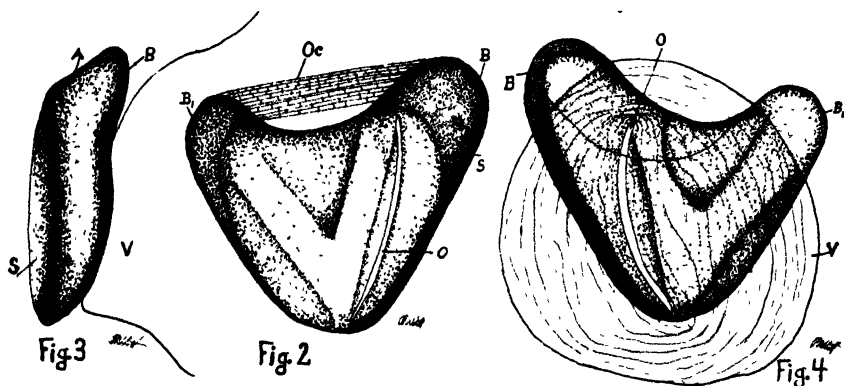
Figure 1. Spiracle and associated structures of the granary weevil. S, spiracle; A, trachea between spiracle and bow; B, chitinous bow; V, vesicle or inner chamber; T and T', the dorsal and ventral branches of the principal tracheal trunk.

muscles (Oc.) connecting the divergent apices of the triangular plates. Figures 2 and 3 represent the outer and side aspects respectively of this mechanism. Figure 4 represents a view from the interior of the insect body toward the spiracle. The air chamber (V) is united to the margins of the slit between the two plates.

The margin of the plate B is darker in color than the remaining portion, and is probably highly chitinized. The central portions of plate B₁ are elevated above the remaining portions, and are darker in color.

These drawings do not include the trident hairs that are found on the plates, and are longest along the margin of the slit, across which they interlace.

I am at a loss to explain the presence of the chitinous bow found near the spiracle of the granary weevil. Inasmuch as the whole tracheal system of this species is quite rigid, the presence of an occluding apparatus seems unnecessary. Indeed, as Krogh (1920) has stated, such a system indicates a type of respiration mostly dependent upon diffusion.



Figures 2, 3 and 4. Spiracle and associated structures of the corn billbug.

S, spiracle; B and B', chitinous plates; O, slit between plates; V, air chamber; Oc, occludor muscle; A, atrium.

The nature of the tracheal system lying between the spiracle proper and the bow is also an enigma. Its position suggests an atrium, but it differs from a true atrium in various ways, especially in having tenidia. Imms (1924) states that the atrium regularly "lacks tenidia" (p. 106). Either this case is an exception to Imms' claim, or what seems more probable, the atrium has disappeared. It is also significant that the trachea of the granary weevil is constricted near the chitinous bow, just as the air chamber of the billbug narrows to communicate with the slit between the two plates.

That the granary weevil is in a state of degeneration is demonstrated by its lack of metathoracic wings. May not the spiracular occluding apparatus be in a state of degeneration from the more primitive type found in the billbug?

In conclusion I wish to express my appreciation to Dr. R. H. Painter, Dr. R. L. Parker, and Dr. R. C. Smith, all of the Kansas State Agricultural College, for aid in this and related problems.

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ENTOMOLOGICAL SENTIMENT.

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To be called a sentimentalist does not always carry distinction. Neither does it in any manner describe the individual referred to. Sentiment is to most of us a vague term denoting something of special meaning to each. However, in the main, we all think of it as somewhat beneath the dignity of mature masculinity. It is defined in many ways, but in my brief discussion I am thinking of this definition, i. e., a decision of the mind formed by thought, deliberation and reasoning. Recognizing this meaning as such, is there a place in the study of entomology for sentiment? It is to be supposed that the older members of our profession who have maturity, experience and historical background are the ones most likely to approach feelings of this sort, while the rest of us can only hope to acquire the same by continuous, energetic study.

As a professional science, entomology is comparatively young in this country. In fact it is less than one hundred years old. And these few years have been crowded to the brim with so much energy, determination and accomplishment that there has been little time for anything excepting the immediate demands. Occasionally, we pause to look back at the landmarks in the distance and attempt to evaluate the lives and contributions of the outstanding men in this science. Only by so doing can we hope to create and develop a professional consciousness, which I choose to call sentiment.

As a prelude to the more serious aspects of our program this year there are several papers devoted to retrospect of this sort.

In our associations with our living brethren we are not likely to exchange sentimentalities. Most of us do have some feeling and reverence for our teachers and the older entomologists whom we have learned to admire without any ideas of suspicion or jealousy. But here, also, we are likely to find that what few real sentiments we do possess are not shared in common by our associates.

It is perfectly obvious, therefore, that to get anywhere in the discussion of this topic I must turn back the pages of time and look into the past for the subject material which I wish to place before you who are gathered here today. No single thing has given me a greater amount of real pleasure than the study of the history and development of entomology in this country.

As a starting point we might first think of John Bartram (1699–1777), the first American to publish notes on insect life.¹

With a knowledge of Bartram's activities in the botanical field, his connection with the American Philosophical Society, with Benjamin Franklin, Thomas Jefferson, and other patriots, and his timely contributions in entomology, one cannot visit the stone house wrought by his own hands and the quaint little garden on the banks of the Schuylkill River in Philadelphia, without a feeling of profound respect. Yet how many entomologists visiting this historic city have paid homage to Bartram's shrine?

Or if more precise, we might begin with Frederick V. Melsheimer (1749–1814), generally considered to be the founder of American Entomology. Who can read Hagen's² admirable account of him without a genuine thrill of pride in this early pioneer in a field then so new as to be practically unknown.

Thomas Say (1787–1834), the father of American Entomology, needs no advocate. His resting place at New Harmony, Indiana, has been made sacred to all entomologists by the pen of the late F. M. Webster, in a series of articles in *Entomological News*.³ Although his grave is marked by a monument,⁴ it was not erected by an admiring public or by followers of the profession which he did much to establish. One can neither read nor write the scientific names of many of our most important American insects without recalling the early endeavors and hardships of this great naturalist. The grape leafhopper, box elder bug, chinch bug, ashy-gray ladybird beetle, Colorado

¹An account of some very curious wasps' nests made of clay in Pennsylvania. *Philos. Trans.* (London), 43, No. 476, pp. 363–6, Figs. (Read by P. Collinson, April 25, 1745).

²Hägen, H. A. *Can. Entom.*, Vol. 16, pp. 191–197, (1884).

³Vol. 6, pp. 1–4, 33–34, 80–81, 101–103, pls. 1, 2, 4, 5, (1895).

⁴This monument of white marble was erected in 1846 by Alexander Maclure, brother of William Maclure, and is situated behind the Maclure residence in which Say died on October 10, 1834. *Entom. News*, Vol. 6, p. 101, (1895).

potato beetle, bean weevil, woodland malaria mosquito, Hessian fly, peach tree borer, odorous ant, common tarantula hawk, and many other outstanding insects named by him, testify to the importance of his contribution to entomology. I hope that in the not far distant future, the entomologists from all over this continent will organize a great pilgrimage to his tomb as an expression of the respect and high regard to which he is entitled, as well as a means of making it one of the historic spots in America. We, more than any other scientists, should lead the way to his grave.

The tendency to exclusive specialization among entomologists is gradually, I think, giving way to the realization that, after all, a sound training necessitates an understanding of many particular fields. Whether this is true or not, all appreciate the value and place of specialization in both systematic and economic studies. Such a society as this co-ordinates and promotes a unity of endeavor and feeling among all specialists and breaks down the barriers of class exclusiveness.

Insofar as my presentation is concerned, it makes no great difference whether this idea regarding particular subjects is accepted or not. One can find enough in every specialty to stimulate feelings of genuine sentiment. But the wider the individual horizon the more there is to be found in the lives and works of his predecessors.

Among the pioneers, William D. Peck and Thaddeus William Harris, of Massachusetts, and Asa Fitch, of New York, truly led the way. What they meant to those who followed may be illustrated by the words of Prof. J. H. Comstock at the Toronto Meeting in 1922.⁵ After a small laboratory had been established for him at Cornell, he states, "I was very anxious to learn how to do my work. Up to the time I was made instructor in entomology (1857), I had no assistance whatever in entomology. So I made a pilgrimage to Salem, New York, to visit Dr. Fitch. That stands out as one of the bright memories of my experience." It is to be remembered that the pioneers had no such opportunities to seek advice. Peck became interested and instructed in entomology by the help of a copy of Linnaeus' *Systema Naturæ* taken from a shipwreck near his home on the coast of New Hampshire.

⁵Jour. Econ. Entom., Vol. 15, p. 33, (1922).

The pioneers were followed by the great constructionists, H. A. Hagen, S. H. Scudder, A. S. Packard, B. D. Walsh, Henry Skinner, S. W. Williston, E. T. Cresson, C. J. S. Bethune, J. L. LeConte, Geo. H. Horn, H. H. Behr, Henry Edwards, and many others. The only monuments left to their memory are those made by themselves, namely, their published works and their collections. While all of us are cognizant of the worth of their writings, few of us hardly appreciate the value of their collections! Fortunately some of our museum specialists do and it is to be hoped that the same care and vigilance long kept by Samuel Henshaw of the Cambridge Museum will be emulated in all museums in the present and future. In this relation I recall the significant words of Geo. H. Horn in connection with his visits to the LeConte collection at Cambridge: "Annually (since taking the LeConte collection to Cambridge) I have made one or two visits for the more accurate study of its types after a thorough study of my own material had been completed. In that collection I find not only the bare facts, for which I seek, but much besides. In the more than thirty years of our association there is not a box which has not been before us in the topic of discussion or for consultation. Every one recalls its memories, and even particular specimens recall incidents of interest. To me such a visit is, therefore, more than the comparison of specimens, it puts me in touch with a friend. . . . I regret greatly that many of the traditions of the collection are known only to me."⁶

Until we are ready to build monuments of another kind in honor of these men who have gone before, we are charged to preserve their collections. This is now being done in all of our great museums which are destined to become the great and sacred entomological shrines, if not for us, for those who follow! With a knowledge of the lives and activities of these men we are in a position to get a great deal more from their collections. Some few years ago I visited a great museum and in common with most folks looked over the conspicuous displays on the main floors, never knowing or dreaming that in the attic was one of the most valuable insect collections in America. How many opportunities are thus lost by a lack of a knowledge of a historical or sentimental background! On this trip I revisited

⁶Entom. News, Vol. 7, pp. 49-50, (1896).

the same museum for the express purpose of retrieving the previous losses.

The early great teachers might be mentioned next: H. A. Hagen, C. H. Fernald, A. S. Packard, A. J. Cook, T. H. Comstock, Herbert Osborn, Lawrence Bruner, and many others. Their contributions of text books and trained students have exerted the greatest influence upon entomology as it is still being taught today. We may be rising a little higher and going a step further in our instruction, but we are still building upon the foundations laid by them.

The organization of economic entomology fell to the lot of T. W. Harris, Asa Fitch, B. D. Walsh, Townsend Glover, C. V. Riley, Cyrus Thomas, J. A. Lintner, C. H. Fernald, H. G. Hubbard, Otto Lugger, William Saunders, M. V. Slingerland, and a few others, who established here in our rapidly expanding country a type of work never dreamed possible, and still unrealized in most other countries. To these men we owe the establishment of entomology as a practical profession and they made the places which most of us occupy today. To Fletcher only has an outward sign of recognition been made. A memorial fountain was erected by his associates and fellow workers at the Experimental Farm, Ottawa, Canada, July 19, 1910.⁷

Perhaps the most lasting contributions were those made by the early great systematists who explored the unknown and brought order out of chaos and left us an inheritance of facts upon which all of our present fundamental knowledge is based. Thomas Say, H. A. Hagen, A. S. Packard, S. H. Scudder, E. T. Cresson, C. R. Osten Sacken, A. R. Grote, D. W. Coquillett, W. M. Ashmead, J. B. Smith, J. L. LeConte, Geo. H. Horn, T. L. Casey, P. H. Uhler, and a great many others, have each made more valuable contributions along this line than most of us can ever hope to accomplish. They had unique opportunities and they made the best of them!

Obituaries are notably lacking in information relative to the actual burial places of practically all of these notables and I wonder if all of their last resting places are known at the present time.

⁷Can. Entom., Vol. 42, p. 265, pl. 7, (1910).

In so short and hasty a sketch it is only possible to indicate the background of our profession and to mention the fact that we have been endowed with a hard-earned heritage, the importance of which few of us realize. What are we to do about it? Do we owe anything to these benefactors? Have we any responsibilities excepting to use of their substances such as will enable us to make better livings for ourselves?

Dr. Howard more than any other living man in America has been most interested in this line of thought. He has kept us informed concerning the past. His stories and reminiscences have brightened many an entomological gathering and there has always been a keen interest and quick response to his contributions.

As a closing suggestion I have thought that it could be arranged by the different societies and associations to raise or set aside certain funds yearly for the sole purpose of placing suitable memorials at the resting places of some of these great leaders in entomology, as a recognition of their services to the world and to preserve that information for posterity. That there is not more sentiment in entomology is largely due to the fact that we have not yet aroused ourselves to the full responsibilities and privileges that are ours!

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APHELINUS MALI AND ITS TRAVELS.

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The world of economic entomology has known in a general way that *Aphelinus mali* Hald., a North American parasite of the woolly root-lice of the apple (*Schizoneura Eriosoma lanigerum* Hausm.) has during the past nine years been carried to many parts of the world and that in some places it has been of great help to apple-growers. But the whole story has not been told, and only a few know it in more than a fragmentary way. This is an attempt to bring all the facts together as a contribution to the rapidly growing literature referring to natural control.

The woolly root-lice of the apple (*Eriosoma lanigerum*, Hausmann), now known in this country simply as "the woolly aphid," although probably of American origin, has become a cosmopolitan pest of the apple and the pear.

Making its appearance in England toward the close of the eighteenth century, it became known as "the American blight"; and either from England or from America it has been carried to many different parts of the world, probably on nursery stock.

The question as to its American origin has probably been settled, and it is likely to have been an indigenous pest of *Crataegus* and to have established at a very early date an alternate food plant in the American elm.

It is probably a fair generalization to state that in the more southern part of the United States, and in British Columbia which, warmed by the Japanese current, has a mild winter, the insect lives upon the roots of its host plants, causing swellings and other deformations and interfering seriously with the sap flow. In such regions also a certain number of the lice are to

be found above-ground on sprouts from the main trunks of the trees. Following out this same generalization, in the more northern part of the United States root damage is very rare and the above-ground individuals are almost the only ones found. Perhaps climatic conditions, however, do not control, but rather soil conditions. In sandy, easily permeable soil, the root form abounds, and it is a question whether such soil is at all well adapted to the growing of apple orchards. Surely in other parts of the world the above-ground individuals prevail and often do serious damage.

Throughout the apple-growing regions of the central strip of the United States, the woolly root-louse has an important parasite, a minute Chalcidid fly known as *Aphelinus mali*; but this important parasite, from the very nature of its structure, is confined in its parasitism to the above-ground individuals of the woolly louse—it cannot penetrate the earth to the root forms.

This parasite, therefore, is not of especial importance in the apple-growing regions where the work upon the roots is the important damage to the orchards, although even here it fills a restricted role of usefulness in parasitizing the small proportion of the lice which are to be found upon suckers and in knotholes in the trunk.

But in Europe, in parts of South America, in New Zealand, and in localities in South Africa, where the greatest damage is done by the aphid above ground, this parasite bids fair to be of great assistance to the growers of apples and pears.

The woolly aphid, when it occurs above ground, is destroyed by a large number of predatory insects, just as are other aphids, notably the larvæ of Syrphus flies, the so-called aphid-lions (larvæ of Chrysopa and Hemerobius), and others; and these predators frequently destroy the aphids in midsummer rather completely, destroying at the same time any parasites that they may contain.

Although I studied *Aphelinus mali* as early as 1879, when I found it parasitizing woolly aphids on the suckers of certain Russian apple trees grown upon the grounds of the Department of Agriculture at Washington, I never thought of it as an important enemy of the species, from the fact that it did not touch the aphids really responsible for the great damage, namely, those on the roots.

Dr. Paul Marchal, however, with his knowledge of the damage done by this aphid to the apple and pear trees of France, largely above ground, began to show an interest in *Aphelinus mali* and the possibility of its acclimatization in France, as early as 1910. No attempts to send living parasites to him were made, however, until after the close of the World War; and the first attempts, by mail, were unsuccessful.

A successful attempt, however, was made in the summer of 1920. The details of this are rather interesting.

Dr. A. C. Baker succeeded in getting together several lots of apparently parasitized aphids from both apple and elm trees at Vienna, Va., and these were packed in five small boxes wrapped together. The writer was about to visit Europe, and took them with him. There were some necessary changes of temperature on the journey. I started from Washington on May 14, and the package remained at the current temperature over night on the window sill of a room in a New York hotel. We sailed on May 15, and the package was put in charge of a steward who kept it in the cold room of the steamer and reported temperatures daily ranging from $37\frac{1}{2}^{\circ}$ to 40° (F.). Arrived in London late at night on the 24th, and the package again remained on the window sill of my hotel room. On the morning of the 25th it was taken to a fishmonger's and kept in his cold room while the writer attended certain scientific conferences in London. On Saturday, the 5th of June, the package was taken from this cold room at night; was again left upon the hotel-room window sill during the night, and on Sunday, the 6th, was carried with my personal luggage to Paris; arrived at Paris about four in the afternoon and was met by Doctor Marchal. We proceeded immediately to his laboratory where he had prepared certain small infested pear trees under gauze covering. The boxes were opened, and the contents were shaken out on blotting paper. A large number of the *Aphelinus* had emerged during the journey, and were dead. Not one was alive.

This was a great disappointment to the writer and to Doctor Marchal and his assistants. However, the material was all placed under the covering of the little infested pear trees and watched daily by a laboratory assistant. It was feared that the opportunity had been lost, and that all of the parasites had emerged during the warmer periods of the journey.

After three days in Paris, Marchal and I started on a journey to the south of France. On the 19th of June, while at Montpellier, we received a telegram from Paris stating that eleven living parasites had emerged from the remaining aphids. On the 24th another telegram was received, at Menton, stating that thirty more living specimens had issued.

From Menton, I went down into Italy while Doctor Marchal returned to Paris and began at once to attempt to colonize the parasites. From that time there was no difficulty; and when I made my final call at Marchal's country place at Antony near Paris, the first week in August, the great-grandchildren of the parasites I had brought over were swarming almost by the million in the large cages that had been erected for them and in the open among the woolly aphids fixed to the trunks and branches of both apple and pear.

Since that time the species has perpetuated itself in France. Its numbers have been greatly reduced each summer by a scarcity of food, the work of the predators of the aphids having been so complete. But colonies have been sent to several points in France where regional laboratories exist, and the *Aphelinus* at this date of writing (December, 1928) may be said to be a permanent element of the French fauna.

It is a simple matter to carry plants from one part of the world to another, even from the north to the south. Such a plant has comparatively a long and progressive life, and the only factor to be considered is its ability to grow in the new environment. But with insects the case is different. The life of the individual is short, even from the egg to the death of the adult, and each species has become accustomed to the seasonal changes in its original home. Therefore, while it is comparatively easy to carry insects from one country to another if they are in what may be termed parallel life-zones, or rather regions having nearly the same seasonal changes, it is a very different thing to carry them with hope of success from far above the equator to far below the equator (or the reverse), since the seasons are diametrically opposite; and an insect starting from New York at the beginning of winter will arrive at, say Rio de Janeiro, in the middle of the summer, a fact which one would naturally expect to be rather disturbing to the insect's economy.

But it turns out that there are certain species which can endure this radical change of habitat apparently with perfect equanimity, and this *Aphelinus*, fortunately, turns out to be one of these species. In fact, rarely in the course of all of the work in the carriage of parasitic insects from one country to another that has been carried on here and there for over forty years has a parasite been found that is as useful and adaptable and as potentially cosmopolitan as *Aphelinus mali*.

Following the successful introduction into France just detailed, sendings were made by the Bureau of Entomology to Uruguay and New Zealand and by these countries and France to other countries.

Although the specimens carried to France were all collected at Vienna, Virginia, by Dr. A. C. Baker, those sent to South America and New Zealand came from various sources in the United States. The following entomologists collected infested apple twigs and sent them to Washington, either to Doctor Quaintance or to Doctor Baker, and they were then sent abroad either by these gentlemen or by myself:

B. A. Porter, Wallingford, Conn., and Vincennes, Ind.

D. Isely, Bentonville, Ark.

E. R. van Leeuwen, Cornelia, Ga.

G. A. Runner, Sandusky, Ohio.

W. F. Turner, Blue Ridge, Ga.

A. J. Ackerman, Bentonville, Ark.

E. J. Newcomer, Yakima, Wash.

In addition, material was sent which had been collected by P. W. Mason, at Arlington, Va., and by E. H. Siegler, at Sligo, Md.

Table I shows these countries alphabetically. It indicates whence and when they received the parasites, and the results so far reported. The pages that follow the table consider each of the countries separately, and again in alphabetical order.

TABLE I.

COUNTRY	WHENCE RECEIVED	WHEN	RESULTS
Argentina . . .	Uruguay	Jan., 1921..	Well established. Excellent results.
Austria	No infor.	No infor.	No information.
Australia	New Zealand..	1922-23.	Doing good work at many points.
Belgium	No infor	No infor.	No information.
Chile	Uruguay	1922.	Well established in 1927.
England	France	1923.	"Usefulness very limited." (Fryer).
France	U. S. A.	June, 1920..	Well established. Effects variable.
Germany	Uruguay	1923.	Apparently established.
Holland.	France	1924.	Widely distributed and well established.
Italy	France and Uruguay .	Jan., 1921..	Well established. Doing excellent work in northern and central Italy.
Japan	U. S. A.	1926.	Failed to establish.
New Zealand	U. S. A.	1921.	Complete success reported by 1925.
Poland	England	1928	Too early to announce results.
South Africa	U. S. A	1920.	Variable results—some apparently very good.
Spain	Italy and Uruguay . .	1926.	Last reported results far exceeded expectations.
Switzerland..	Germany.	1923.	No recent report.
Uruguay.	U. S. A.	1920.	Great success. "Woolly aphid well under control."

ARGENTINA.

In the early spring of 1921, Dr. Roberto Sundberg, the Chief of the Defensa Agrícola of Uruguay, sent to the Defensa Agrícola of Argentina a colony of the *Aphelinus*. Doctor Sundberg had received original living material from the Department of Agriculture in Washington in January, 1921. Señor E. E. Blanchard and Ing. Carlos A. Lizer y Trelles, acting for the Argentine organization, started these colonies in the fruit-growing region of the so-called delta of Argentina. The results were very satisfactory, and the following year they established the parasite in all of the principal apple-growing regions of the district.

The Sociedad Rural of Argentina also introduced the *Aphelinus* from Uruguay, in the early part of 1922, under the auspices of the Biological Institute of the Society. The

material was placed largely in charge of the late Señor Juan Bréthes, who reported in the Annals of his Society of the 15th of March of that year that there was every indication that it had proved effective and that parasitized material was then being distributed.

Since 1922 no further introductions have been made. Señors Blanchard and Lizer y Trelles have made numerous inspections from time to time, and I learn from correspondence with Señor Blanchard that it may safely be stated that the results obtained have been for the most part extremely satisfactory. He wrote me in July, 1927, that in the Delta region the parasite seems to find ideal conditions and that it was at that time difficult to find a living woolly aphid. He said further that the varieties of apples that were abandoned prior to 1921 on account of their susceptibility to attack by the woolly aphis, were in 1927 grown with impunity. However, the pest had not entirely disappeared. He stated that in the springtime it was not uncommon to find an occasional small colony on the main trunks of the trees close to the ground. These, of course, were established by migrating root forms, and were soon destroyed by the parasites. This excellent condition had been observed in all of the apple-growing regions of the province of Buenos Aires, as well as in the littoral zones. Elsewhere, as in the Rio Negro district and in the apple-growing regions of Mendoza and San Juan, the results had not been so good. Possibly the high altitude or the cold winters or the scarcity of alternate hosts may account for this difference. Nevertheless, even in the regions indicated the parasite was said to be doing good work, and it was Señor Blanchard's hope that it was possibly developing a resistant strain which will be able to withstand the unfavorable conditions.

AUSTRALIA.

The *Aphelinus* was not sent direct from the United States to Australia, but after its establishment in New Zealand by Doctor Tillyard and his assistants it was sent to the former country from the latter. In his report on the work during the season of 1922-23, Doctor Tillyard wrote that Australian applicants would be supplied with infected twigs sent out during the winter (July) by post. He urged all New Zealand orchardists who apparently had already a good supply to help their Aus-

tralian friends by sending them twigs bearing parasitized aphids.

Through consignments which were sent by Doctor Tillyard to Western Australia and Queensland, the species was successfully established, and the work of distribution to orchardists in those two states was carried on during the summer of 1924.

It is very interesting to note that, although a consignment was sent to New South Wales, it was lost through over-strict application of quarantine regulations. Further supplies were sent, however, during the winter (July-August, 1924).

The earliest report from Queensland seems to have been published by Mr. H. Jarvis in the Queensland Agricultural Journal for May, 1924. He states that, accompanied with Mr. A. A. Girault, he visited Stanthorpe where more than fifty parasites had been liberated. They found other parasites some distance from the tree on which the first consignment was liberated, and concluded that the parasite had become established.

In Leaflet No. 128, Mr. L. J. Newman, Government Economic Entomologist of Western Australia, describes the introduction into that state, describing the liberation of the parasites on August 31 and September 28, 1923. The first generation from these emerged October 23, and within three months there was an almost total parasitism of the visible aphids on the original tree. Later the parasite was found one hundred yards away. On the 27th of January, 1925, Mr. Newman wrote me that the parasite was established in almost every apple-growing area in the state.

In the Journal of the Department of Agriculture of Western Australia for December, 1926, Mr. Newman stated that *Aphelinus mali*, after a year, parasitized nearly all the "black citrus aphid (*Siphonophora* sp.)." I questioned this statement at the time, and Mr. Newman promised to send specimens but none have ever come. Doctor Tillyard, in Washington, in June of 1928, said that Mr. Newman had also promised to send him specimens, but that he had not received them. I believe that all of the records of the rearing of *A. mali* from aphids that have not a waxy covering are due to wrong determinations.

In Queensland the good work of the parasite continued and spread. Mr. R. Veitch, in his Report of the Chief

Entomologist (Report of the Department of Agriculture of Queensland, 1926-27, Brisbane, 1927) wrote, "*Aphelinus mali* Hald. continues to be of great value in the control of *Eriosoma lanigerum* Hausm. (woolly apple aphid)."

In 1926 there were several mentions of *A. mali* in Australian publications. W. B. Gurney, in the Agricultural Gazette of New South Wales, February 1, 1926, showed that 16,000 living individuals of *A. mali* had been distributed in that State. H. M. Nicholls, in the Annual Report of the Government Microbiologist of Tasmania, reported that *A. mali* had been introduced from Western Australia and was apparently already multiplying rapidly and largely reducing the numbers of the aphid. In a later report, Gurney stated that arsenical sprays do not affect the parasite and contact sprays have little direct effect upon it. Where it has been introduced on one or two trees in an orchard, however, these trees should be left unsprayed. He also advised that prunings of trees showing dead parasitized aphids should be kept to start fresh colonies of the parasite in the spring.

In Queensland, remarkable success was reported in 1925, Mr. Jarvis stating that the parasite had been found as far as three miles from the point of liberation. However, he made a further statement that the parasite seems to attack any dark-colored aphid. This appears to be a mistake, and the inference is that some other parasite is at work. In August, 1926, Jarvis reported that, although a few individuals may emerge earlier, the adults mostly appear about the end of August and the parasite continues to be active until about the end of April. The life-cycle occupies about a month; so that five or six broods would be possible there during the season. He found that adults fed on honey and water lived for twenty-one days in the insectary. He makes the further interesting statement that many of the parasites hibernate in the dead bodies of the aphids attached to cloth bands around the trees, and suggests that such bands, with all prunings, should be stored in a cool place during the winter and returned to the orchard in the spring.

Several interesting articles have appeared in the Journal of the Department of Agriculture of Victoria by G. T. Levick, Science Field Officer. These were summed up in one paper published in the June, 1925, number of the Journal. The original stock was received from Tillyard in New Zealand in

October, 1924. Parasites were liberated at the Burnley Horticultural Gardens, on a tree badly infested with woolly aphis, which had been especially prepared and covered with "butter-cloth." A month later another consignment was received from Newman of Western Australia. At the date of the writing of this latter article, the *Aphelinus* had been distributed to more than fifty orchards throughout the State of Victoria, and in practically every case of those that had been inspected the parasite was well established. Mr. Levick found the period of development of a generation to be shorter in Victoria than in New Zealand—that is to say, three weeks instead of five.

The parasite was introduced into Tasmania from Western Australia in November, 1924. H. M. Nicholls, in the Report of the Agriculture and Live Stock Department for 1924-25, states that as the adult parasites appeared they were liberated in various orchards in both the northern and the southern apple-growing districts. He stated that they took kindly to the climatic conditions and at the time of the report were everywhere multiplying rapidly. In some cases they had already reduced the woolly aphis to very small numbers. The winter was passed in the larval stage in the body of the parasitized aphid.

AUSTRIA.

In a paper entitled "Plant Protection in Austria," read at the meeting of the Deutschen Gesellschaft für angewandte Entomologie in Vienna in 1926 (published in the *Verhandlungen of the Society for 1927*), Dr. Bruno Wahl mentions the damage done by the woolly aphis and states that the acclimatization of *Aphelinus mali* will be undertaken.

BELGIUM.

In his summary report of the work accomplished in his laboratories in 1925, Marchal mentions the fact that two new sendings of this parasite had been forwarded to Gembloux, Belgium, where the multiplication of the insect proceeded in a very favorable way. We have heard nothing further about the status of the insect in that country.

CHILE.

In 1923 the Defensa Agrícola of Uruguay sent a colony of the parasites to Chile, and excellent results from this importation were reported by F. L. Crouse. The acclimatization was evidently accomplished without difficulty, and we have seen an article on the biology of the species by J. Torres Ortiz in *Agronomía* (Santiago, Chile, November, 1927). In this article, the author states that the females lay five or six eggs an hour, always in the early morning or towards nightfall. Most adults emerged in 20 to 29 days after egg-laying, although sometimes they were delayed until 32 to 50 days. No males had been noticed. During his study, covering two years, there had been an average of six to seven generations a year, the adults living to a maximum of 32 days. The statement is distinctly made that the winter is passed in the egg stage within the aphids that have migrated to the roots of apple trees.

ENGLAND.

In 1922, according to an interesting article by R. Stenton published in the Journal of the Ministry of Agriculture of London in 1925, it was decided to go into the experimental introduction of the *Aphelinus*; and in March, 1923, material was received at the Harpenden laboratory of the Ministry of Agriculture and Fisheries from Paul Marchal of Paris in the form of dried aphids containing full-fed larvæ of the parasite. According to Mr. Stenton's report, adults emerging from this original material multiplied at a prodigious rate in captivity on apple trees infested with woolly aphids during the following summer, and by 1923 it was possible to consider introductions in the open at various chosen centers. The first lot of trees at Harpenden were in pots and were kept in the insectary, and a large stock of the parasites has been maintained there ever since, a second insectary being added in 1925, according to information received from Mr. J. C. F. Fryer. Stocks were also established in insectaries at the Long Ashton Fruit Station, Bristol, and at Seale Hayne Agricultural College in Devon. In 1924, after experimentation, it was found to be the best method to send in the early spring several apple twigs bearing one hundred or more parasitized aphids, the twigs being enclosed in a cage of wire gauze with a mesh large enough to

allow the *Aphelinus* to escape but small enough to keep out ladybirds. With these little cages were sent instructions to tie them to the trunk or branch of trees where there was probability of a strong infestation. They were sent in all to 26 different localities.

Prior to 1928 small introductions, usually consisting of only one cage, were made in a large number of centers each spring. In 1928, however, all the material available was divided into two lots each consisting of approximately three thousand parasitized aphids, and these were introduced into single orchards at Chislehurst (Kent) and Ledbury (Worcestershire). As appears from Mr. Fryer's published report on Insect Pests of Crops for 1925-1927, issued in 1928 (Miscellaneous Publications of the Ministry of Agriculture and Fisheries No. 62), most of the introductions apparently resulted in failure. As to the remainder, although the parasites persisted for a time, in no case do they seem to have become definitely established. The greatest measures of success were reached at Broadway (Worcestershire), at Barnstaple (Devon) and Usk (Monmouthshire). Doctor Fryer concludes that the difficulties in establishing the parasites appear to be due to three causes, (a) The irregularity of the occurrence in England of the woolly aphid; (b) The tendency of the parasite to emerge too early in the spring, before the woolly aphid has become abundant; (c) The adverse effect of the dull, wet or cool weather prevalent in England in the spring. The adult *Aphelinus*, delicate creature that it is, with wings that are easily clogged by moisture, cannot spread and does not seem to multiply rapidly under such conditions. This seems natural enough, and I have always attributed the abundance of aphids in the wet springs in the United States and their disappearance in hot weather partly to the fact that their effective parasites of the Braconid subfamily Aphidiinae cannot move about with moisture-clogged wings.

Doctor Fryer concludes from the work so far done that the usefulness of this parasite under English conditions will be very limited.

In a letter received from Prof. F. V. Theobald, of Wye (Kent), the same point was advanced, although Kent is I believe one of the sunniest counties in England. Under date of June 19, 1928, he wrote, "I am sorry to say, *Aphelinus mali*, which I turned out under favorable conditions, has been a failure.

Definitely it is no good in this part of England. In one orchard it spread to a few trees near at hand, and then died out; in the other it was even worse. I gather that it has been no good anywhere in this unkindly climate."

FRANCE.

The first efforts to acclimatize the parasite in France, after I carried it over successfully in the summer of 1920, were in the neighborhood of Paris. Centers of rearing under control and of dispersion were started at Antony, at Bourg-la-Reine and Montreuil. Soon the entomological stations in the provinces were sent colonies which allowed them to rear the parasites successfully. Every year afterwards from the different centers, especially from Paris, sendings were sent to correspondents in the different provinces or in other countries.

The testimony as to the results obtained down to 1923, when Doctor Marchal mentioned the subject in his report as Inspector General, was very unequal; failures apparently resulted in some cases and successes in others. In 1923 colonies were sent out to eleven departments of France; also to England, Roumania, Algeria and Morocco. Doctor Marchal reports also that good news has been received from colonies which were established, through his assistance, in 1922 in Switzerland (Lausanne) and in Italy (Florence).

In an interesting report published in 1924, entitled "The Acclimatization in Normandy of *Aphelinus mali*," by R. Regnier, we find the following account (fully translated):

Biology of the Aphelinus.—The female of the *Aphelinus* punctures successively a certain number of plant-lice and lays in each one an egg which gives birth to a larva which feeds upon the internal organs of the plant-louse. Marchal estimates 60 as the minimum of the offspring of a single female. A parasitized plant-louse speedily loses the waxy filaments, turns black, and dries up, without any especially noticeable deformation. It is necessary to know this aspect of the plant-louse when one is attempting acclimatization. One must not take as parasitized plant-lice those adults which, under the influence of different conditions, have lost a large part of their waxy covering. *The parasitized woolly aphid becomes plainly black.*

One must not take for parasitized woolly aphids green plant-lice parasitized by *Aphidius*. Green plant-lice, as a matter of fact, are often mixed with the woolly aphids upon young twigs, notably in the nurseries. When these are parasitized they assume a characteristic inflated condition and become gray in color.

At the end of 20 days—sometimes more, according to the season—one *Aphelinus* issues from each parasitized aphid. Nothing is easier to recognize than the empty aphids. They show a circular hole pierced by the *Aphelinus* in issuing, and this is visible to the naked eye.

The life of the *Aphelinus* is generally short. The number of generations is seven to eight each year. In the laboratory at Rouen we have had the earliest issue in the first days of April and the last ones in October. Normally the appearance of the parasite coincides with that of the woolly aphid. Sometimes, however, it issues some weeks in advance, as happened in Normandy in 1922. The plant-lice had not yet crawled up from the earth when the *Aphelinus* came out, and there resulted an enormous loss of parasites, which in other cases has checked acclimatization.

The parasites fly little. They hide themselves often under leaves, and jump with the greatest facility. This makes an easy way of recognizing them without the trouble of examining their specific characters. Marchal estimates their dispersion at about 400 meters.

The parasite hibernates well in Normandy, enclosed in the plant-louse which it parasitizes and from which it issues in the spring.

Acclimatization of the Aphelinus. Rearing.—The acclimatization of an insect parasite of the size of the *A. mali* must be undertaken with certain precautions based upon its biology and upon the conditions under which the woolly aphid lives.

The rearing is now going on by the entomological stations at Paris, Chalette-Montargis, Rouen, Saint-Genis-Laval and Bordeaux, and, by correspondence, these stations are doing what they can to create on all sides, at places where the woolly aphid is most abundant, centers of acclimatization. It is important to increase the number. All groups of agriculturists and horticulturists who are interested in the fight against the woolly aphid should organize a center of rearing which would be able to supply the needs of the region.

The rearing of *Aphelinus* is made in large cages of wooden framework with tarlatan sides, two or three meters long, one and a half meters broad and two meters high, in which should be placed a certain number of small apple trees well stocked with woolly aphid. These cages should be installed in winter, and the trees would better be planted in October. The *Aphelinus* in the parasitized aphids will come on twigs which should be bound with raffia to the enclosed little apple trees. The woolly aphid, thus being protected from the attacks of its enemies, develops with great rapidity, and the *Aphelinus* parasites which come out find abundant host material, multiply, and it soon becomes possible to create thus centers of dissemination. Besides this, thanks to the small mesh of the tarlatan, only the parasites can escape from the cage, while the aphids remain enclosed.

Instructions for dispersion.—If the rearing of *Aphelinus* necessitates certain material and certain expense, it is not so with dispersion. It is necessary to adopt a simple and practical method without expense. In order that the chances may be best, it is necessary to find a place in an orchard especially invaded by the woolly aphid and which will have

plenty of material during a great part of the year for the *Aphelinus* which exclusively attacks this aphid. On the other hand, it is necessary to take certain precautions. Abandoned nurseries, badly cared for gardens, old neglected wall tree, where the aphid is generally increasing will be the most favorable places and should be sought for. Lacking such infested points, the orchardist should use the trees on his own property, choosing those that are most attacked.

The most necessary precautions are as follows:

(1) The twig covered with parasitized aphids should be carried or sent in a box or tube, and should be opened only near the place of acclimatization so that the *Aphelinus* which have issued during the journey will not be lost and can parasitize some colonies.

(2) This twig should be carefully bound with raphia to a branch covered by the woolly aphid.

(3) One should make certain that there are upon this branch no larval or adult Coccinellids nor Syrphid larvæ nor Hemerobiid larvæ, since all these insects are great feeders on plant-lice. It is necessary to search for such enemies and to remove them with fine pincers or with a dissecting needle.

(4) To protect the whole initial experiment, a sack of muslin or tarlatan should be made. This precaution is absolutely indispensable in order to keep predators away from the colony. Experience has shown us that it is necessary to give to this sack a certain rigidity so that it will not be injured by rain or wind. A cylinder should be made with about 10 square centimeters of the muslin, and this should be kept open by a wire drawn in a circle at each end, the two being connected by wire; then, beyond each circle the muslin is fastened to the twig.

When the *Aphelinus* come out of the parasitized aphids a certain number of them will find that the colony offers a favorable place for their development and will lay their eggs in the aphids. A center is thus established, and the *Aphelinus* will multiply, and, escaping through the mesh, they will parasitize colonies of woolly aphid on the surrounding trees.

The best time to begin this work is the end of April and during the month of May. In June there are generally plenty of woolly aphids, but that is also the month in which the greatest number of predators appear. If the attempt at acclimatization is made during this month, the *Aphelinus*, needing several weeks to thoroughly establish itself, will in July no longer find sufficient hosts for multiplication. During certain years when the predators are very numerous, the acclimatization, after a promising beginning, may find itself compromised by an insufficiency of hosts.

There is another method: that of *fixation*, similar to that which we have just described, which has for its end obliging the *Aphelinus* to remain upon a fixed branch. This method takes more care, but it is nevertheless very simple. We recommend the operator to have at his disposal several branches covered with parasitized aphids. One of these branches should be enclosed as we have indicated, but, in place of using *toile à patrons* or tarlatan, one uses *toile à beure*, or, better still, muslin, where the mesh will not permit the *Aphelinus* to get out. After

twenty days, this sack should be changed to tarlatan so that the *Aphelinus* which come out of the newly parasitized aphids can escape and propagate in neighboring colonies. After fifteen days in summer one can see the parasites come out of the plant-lice, and if one or two of them are placed upon a bit of white paper, and if they are black and yellow, and jump, they are without much doubt the *Aphelinus*.

We have the firm hope that some day the raising of *Aphelinus* will be done on a large scale and that the centers of dispersion will be numerous, and that the acclimatization of this precious parasite in France will be of some use. But we must not forget that in the acclimatization of *Aphelinus* we are only adding a new enemy to those which we already had, and consequently we must not be astonished if at certain times, in spite of its help, the woolly aphid will reappear, perhaps even abundantly, during intervals, after which its enemies will in their turn dominate. This is the normal cycle of indigenous pests which have for a long time had their predators and their parasites.

Conclusion.—From all that we have said, it is reasonably sure that henceforth the acclimatization in France of *Aphelinus mali* may be considered as possible; that this parasite withstands our winters very well and multiplies very rapidly when there are abundant colonies of the woolly aphid at its disposition; but that its introduction into our country is still too recent and the number of centers too small to estimate positive results which may come about. It is necessary to leave the entomologist time and material for observation before announcing to agricultural organizations the best ways to popularize the method, to create centers of rearing without which the dispersion of the parasite will never be possible.

This study has no other end than to sum up the condition of our knowledge upon this question and to show the real importance which this new attempt may have some day.

Ever since the first successful introduction in the summer of 1920 Marchal has been rearing the parasite in cages at his country place at Antony and has been making careful studies of its biology. It is hoped that he will publish a full monograph.

On September 3, 1928, he wrote me, in the course of a personal letter:

While waiting to join Madame Marchal in the country, and in order to get exercise, I made during recent dates long walks in the country around Antony, having for my object to determine the area of dispersal of the *Aphelinus*. I have been surprised to find that the present summer, hot and dry as it was, has been very favorable to this dispersal. Upon all the apples, where there had been the least trace of the woolly aphid, I have found the *Aphelinus* in all the communes about Antony and Bourg-la-Reine—that is to say, over a territory having a diameter of eight to ten kilometers. The acclimatization of the species, therefore, has been very well effected in this region to the south of Paris, and it is probable that the area will be enlarged without cessation. However, this will necessitate seasons which are more or less favorable.

GERMANY.

In one of his publications, the Italian writer Malenotti speaks of a correspondence with Stellwaag of Germany in which the latter states that the first attempts at the establishment of *Aphelinus mali* in Germany failed during the first winter from the results of severe cold, the inference being that the species will not stand a temperature of 10° (C.). And on this statement of Stellwaag's, added to his own experience in north Italy, Malenotti advises the keeping of colonies under glass, as we have indicated in our consideration of the Italian work.

The best published information on the subject of the German experiments is contained in an article entitled "The Introduction of *Aphelinus mali*," etc., by R. Schander and O. Kaufmann in the *Zeitschrift für angewandte Entomologie*, 1925, part 3. The experiments were carried on apparently at Landsberg in Bavaria.

The material was received early in September, 1923, from Uruguay. No adults had issued during the journey. Three days after arrival, however, the first ones emerged (The shipment had been kept in the refrigerating room of the steamer). In their rather long article, the German writers describe the oviposition with great care and state that experiments with other aphids than the *Schizoneura* were unsuccessful. The different stages are described, and it is stated that the males appear somewhat earlier than the females and are smaller in size, but considerable variations in size occur with both sexes—sometimes small females are smaller than large males. The first generation in the spring occupies four weeks. In summer a generation may be completed in 14 days. The adults mate soon after emerging and begin to oviposit immediately. The generations overlap during the summer, and an exact record is difficult. The authors think that ten generations is not an exaggeration.

The parasite hibernates as a larva in its host, development slowing down in the fall. In non-heated greenhouses, the first parasites emerged, in 1924, during the middle of April; in 1925, at the end of March. In the open field the first adults were noticed, in 1925, on April 24, at a date when the second generation had begun to lay eggs in the greenhouse. Investigation showed that the period of hibernation could be extended or shortened without injury to the larvæ.

Some interesting observations were made upon the parasitized aphids. The writers state that as soon as these feel that they are mortally affected they separate from the colony in order to hide in cracks beneath scales of bark, or in holes or wounds on the branches. They have often been observed to migrate as far as one meter, and the statement is made that they may leave their old host plant. After a suitable place is found, they are said to fasten themselves to the tree by means of a web or sticky substance so that they are rarely washed off by rain or blown off by the wind, while their natural enemies are not likely to locate them in their hiding places. Part of the parasitized aphids migrate, like the healthy ones, to the roots and seek the covering protection of the soil.

The authors consider the prospects of acclimatization to be very bright, but state that several more years must elapse before assuredness. They consider that the radius of activity and the speed of distribution are very small. The maximum increase of the aphid is certainly much greater than that of the parasite. The writers believe that the growth of resistant varieties of apples is still to be encouraged, but think that the acclimatization of the parasite will be worth while. They do not look forward to a lasting and complete success if the parasites alone are relied upon.

HOLLAND.

In 1924 the Bureau of Plant Diseases of Holland (headquarters at Wageningen) imported a small colony of *Aphelinus mali* from France. In his report for 1925, N. van Poeteren stated that the parasites survived the previous winter and were increasing at the time of writing.

In 1928 the report of the Bureau affirms that the importation was a complete success. It not only had established itself in Holland, but had been distributed to a number of different sections. The demand for the parasitized aphids soon became so great that it was impossible to fill all requests. However, ninety shipments were made, distributed over eighty districts covering the entire country. The results of careful observations made in 1927 indicate that although the parasite had not established itself in all places as well as it did in Wageningen and Lunteren, it had nevertheless surpassed all expectations. It was assumed that it had taken firm hold in places not yet made public.

ITALY.

In 1921 Prof. G. Del Guercio, of the Royal Entomological Station at Florence, imported *Aphelinus mali* from France. His original specimens were received on the 20th of September from France, Gaumont, one of Marchal's assistants, having been sender. A second sending was received at Florence in 1922 from Uruguay and was placed in the garden of the Station. In this garden and in the laboratory, the parasite was studied carefully for a number of years by Del Guercio. In the meantime the French sending had been placed in the orchard of the School of Horticulture and Fruit Culture in Cascine.

The species multiplied rapidly, and different specialists connected with the Traveling School of Agriculture started centers of distribution at various points in central and northern Italy. Prof. E. Malenotti began to publish on the results in 1923, and has since issued numerous papers. He found that in northern Italy the winter of 1923-24 was very severe and the parasites were greatly reduced in numbers by the cold except for favorable localities where special conditions of protection existed. By correspondence with Doctor Stellwaag, of the Agricultural Institute of Neustadt, he learned that exactly the same thing had happened in Germany. He therefore recommended, in a paper published in 1924, that in northern Italy there should always be kept a small supply of very young apple trees infested by parasitized *Schizoneura*, under glass—in greenhouses or in cold-frames. He recommended for this purpose young Calville stock (except the red winter variety) or Golden Reinette or other varieties peculiarly subject to attack by *Schizoneura*. He recommended that young trees should be taken in the middle of November and placed in unheated greenhouses. Tests showed him that a temperature of 10° (C.) stopped the development of the larval parasites, which is resumed the following spring, the first adults appearing about the middle of April. He pointed out that all the other natural enemies of the aphids should be destroyed on these young plants. He indicates that their presence is easily noted by the disorder in the *Schizoneura* colony; where they are present, there remains usually only a scattered area of waxy exudations. As apple trees are not planted in Italy in large orchards, Malenotti states that it is necessary to stock many centers.

Following the cold winter above mentioned, the parasite was again introduced into northern Italy in 1924, and complete reproduction was established in those regions, namely Trentino and Alto Adige.

In one of his papers (published in *Il Coltivatore* of the 20th December, 1924) Malenotti described a migration of 12 kilometers by the *Aphelinus*, the parasite having been found at Desenzano, 12 kilometers from a center in Moniga del Bosco. He considered it largely a matter of wind-spread. I wrote Malenotti on the receipt of this paper and suggested the accidental carriage by some person or persons; for example, one or more of the little parasites might have become attached to the clothing of a man walking through the orchard at the center of distribution, and later, finding themselves at this distance of 12 kilometers in an infested orchard, the parasites, attracted by the aphids, might have left him there. Malenotti wrote in reply that there are hardly any movements of persons or cars between the two places.

In 1925, after careful study of the parasite, Del Guercio issued a long and important paper entitled (translated) "New Contributions to the Study of the Woolly Root-Louse and its Internal Parasite." This publication, which covers 35 pages and carries numerous illustrations, is obviously the result of close and long study. In the course of this study many important points were brought out. One of the most interesting was the discovery of apparently two forms of the *Aphelinus*; the one smaller, which he calls the advance guard, since it is more active and is the form that spreads the species by means of flight; the other larger and more sluggish, appearing after the first invasion of a new colony of the aphid. To one of these forms he has applied the name *Aphelinus mali* Hald., variety *italica* Del Guercio. His descriptions of the two forms indicate not only differences in size but also differences in the proportions of the antennal joints. Judging by the figure on page 23, the variety *italica* is the smaller "advance guard" form, a figure (13) on Plate III obviously representing the larger and more sluggish form. As it happens, however, the so-called new variety to which he has given a special name seems to be the typical form as found in the United States. His observations on the habits of the so-called "advance guard" are interesting. In another publication he reports that, in a single place, he found that the *Aphelinus* had migrated over 400 meters across high walls and

over tall trees. Malenotti, referring to this observation, has stated that he himself at Vicenza noticed a spread of 300 meters. Another interesting illustration of migration is told by Malenotti in *Il Coltivatore* for October 10, 1924. It seems that his friend, Prof. C. Malandra, during the first part of June, started a colony at Lendinara. A few small branches carrying parasitized aphids were placed upon a few low-growing apple trees which were trained along a horizontal wire. Less than $3\frac{1}{2}$ months later Malenotti visited the orchard and found that the *Aphelinus* had become strongly established on tall apple trees fifty meters away and had destroyed nearly 80% of the heavy infestation. Hundreds of thousands of aphids had been killed.

Curiously enough, Del Guercio's figure of his variety *italica* represents exactly the series of males of *A. mali* in the collection of the National Museum, Washington, whereas the form figured on Plate III corresponds exactly to the females in our collection.

In 1921, Prof. F. Silvestri at Portici wrote me for specimens. Knowing that he could get them much more quickly and with less danger of loss on the journey from Doctor Marchal in France, I referred him to the latter. He received specimens from France on July 5, 1922, placed them on badly infested trees in the experimental orchard of the Agricultural School, and a month later specimens of the first Italian generation issued. From these trees in 1922 and 1923 Doctor Silvestri made sendings of the parasite to Caserta, Benevento and to Salerno, localities not far from Naples and lying to the north, the east and the southeast of that city. The species was everywhere very easily acclimatized, but, Silvestri writes me, "Where *Schizoneura* has very favorable conditions of development the parasite has not controlled the pest."

It seems, then, that the species has been established thoroughly in Italy and that, with some care to maintain numerous centers of supply during severe winters, it will continue to be of great assistance to fruit growers. It is not likely, however, that it will prove as perfect a protection against *Schizoneura* as does its relative, *Prospaltella berlesei* Howard, against the white scale (*Diaspis lanatus*). The constant renewal of the above-ground form of the *Schizoneura* from the underground root-form and the fact, pointed out by Lundie, of the continued reproduction of the aphids for some days before the parasitism becomes effective account for the difference in effectiveness of the two parasites.

JAPAN.

Two attempts have been made to acclimatize the *Aphelinus* in Japan—one in 1925 and the other in the winter of 1925-26. The first attempt failed. The receipt of the second sending was acknowledged on April 20th by Professor Kota Monzen of the Imperial College of Agriculture and Forestry at Morioka. They were apparently in living condition. But as we have heard nothing further the probabilities are that again the establishment failed.

NEW ZEALAND.

The story of the introduction of the *Aphelinus* into New Zealand has been well and fully told by Dr. R. J. Tillyard in the *New Zealand Journal of Agriculture* for July 20, 1921. Tillyard and I had met in the summer of 1920 in London when I had in charge the consignment of living *Aphelinus* for France. Returning to New Zealand via Washington before my return, Tillyard arranged with Doctor Quaintance of the Bureau of Entomology to have parasitized woolly aphids collected in the autumn and forwarded to New Zealand. On the 11th of January, 1921, the consignment reached Wellington, and on the 13th of January arrived at Nelson. The consignment contained specimens from the State of Washington, the State of Connecticut and the State of Arkansas. From this lot eighteen living specimens were reared during the month of February. These were placed in different orchards, under gauze. All the colonies failed except one consisting of three males and two females reared on the 19th of February. Early in April adults of the first generation on New Zealand soil began to appear. Doctor Tillyard describes his methods and the disposition of those first appearing. Cold weather put a stop to the breeding early in May. The first New Zealand brood consisted of 142 specimens, the offspring of the three males and two females above mentioned.

In 1922 he published another statement, showing a much greater amount of rearing and distribution in the summer of 1922-23. Again, a year later (1923) he showed a distribution in one province of 5,255 specimens; in another of 6,620 specimens; in another of 15,055 specimens; in a fourth of 2,300 specimens, and in a fifth of 3,825, making a total of 33,055 distributed.

A year later (1924) there was a great increase in the distribution work, and the significant statement was made that "Only three years from the date of its original introduction the parasite has succeeded in practically eliminating the woolly aphis from large areas of orchard country in the Dominion." Again, he states "The letter file devoted to *Aphelinus* at the Cawthron Institute is full of appreciative letters about the work done by the parasite in the orchards of the Dominion during the past year." This was notably so in the Auckland and Nelson districts.

In his report published June 16, 1925, he again gives an account of the distributions and gives a long list of the towns and the individuals to whom consignments had been sent. His total shows a distribution of 112,000 specimens.

Following his paper giving the astonishing results of the work of the seasons of 1923 and 1924, Doctor Tillyard wrote me at length about the possible parasitism of other aphids and also mealybugs, partly inspired to these questions by the observations of Newman and Jarvis in Australia. He also began about that time to speculate about the possible effect of the crossing of two geographical races of *Aphelinus*. He contrasted in his mind the large measure of success which he had obtained with the *Aphelinus* in New Zealand with the lack of success which he had had with the dipterous parasites of the European earwig which he was importing from England about the same time. He noticed that some of the parasitized material of woolly aphis from the United States came from Connecticut and some from Arkansas or Arizona, and he thinks that in the insectary these two strains may have crossed and thus produced a race of great vigor in New Zealand. Writing on May 25, 1925, he insists that the hybridization of distinct biological strains often results in improved vigor even if the original strains are not morphologically distinct. He adds, "Whatever be the cause, the fact remains that *A. mali* in New Zealand is almost unbelievably active and productive, and we all of us owe you a deep debt of gratitude for supplying the original colonies."

In his letter of August 28, he writes, "The immense success of *Aphelinus mali* both here and in Australia has quite altered the outlook for the Cawthron Insitute One man left us his estate (3,000 pounds) as an endowment for research, and another man has given us sixty-five acres of valuable land . . ."

In closing his 1925 report, Doctor Tillyard announced that the following spring and summer only a few trees would be retained at the insectarium for the purpose of raising broods of the *Aphelinus* and that the main object of this would be to have a small supply always on hand in case the parasite should happen to die out in any district owing to the complete destruction of its host. The announcement was made that general distribution of the parasite would not be undertaken in the future as it was then considered that the parasite was at that date sufficiently abundant in almost every part of New Zealand to make it possible for any orchardist to secure supplies locally. As above indicated, this statement was supplemented by the complete list of all applicants who had received supplies during the year. A similar list was published with the previous report.

POLAND.

According to Dr. R. Bledowski, *Aphelinus mali* was imported into Poland from England with the assistance of Dr. S. A. Neave, in 1928, and was liberated in orchards in the vicinity of Warsaw. It multiplied, but at the present time no results have been announced as to successful hibernation.

SOUTH AFRICA.

During the summer of 1920, when the writer was carrying parasitized woolly aphids to France, a South African student, Mr. A. E. Lundie, was studying at Cornell University, Ithaca, New York. Before leaving South Africa, he had been requested by Prof. C. P. Lounsbury, the Government Entomologist of South Africa, to make the attempt to send *Aphelinus mali* to that country. Mr. Lundie made the necessary studies at Ithaca and sent parasitized aphids to Pretoria, where the parasite at once took hold, laid its eggs in native aphids, and soon a new generation began to appear. Distribution of parasitized aphids followed during the next two seasons.

On the 30th of June, 1923, Professor Lounsbury reported as follows:

The distribution of the woolly aphid parasite (*Aphelinus mali*) was continued. Following hailstorms, apple trees in Pretoria, in which the parasite had been established for two years, became heavily infested with the pest insect early in the season, despite its enemy. But as soon as the season advanced the parasite caught up on the aphid and, when winter approached, few live aphid remained, while the trees

were thickly studded with the blackened bodies of victims of the parasites. The parasite was found to spread quickly from garden to garden. It was observed well established about five miles away from where any specimens were liberated.

In 1926 Professor Lounsbury reported that the parasite was spreading naturally in many localities but had failed to establish itself in the Cape Peninsula. He stated that "The parasite is ineffective in the spring but may control the root-louse by midsummer and so check outbreaks in seasons and places where the lice are not killed naturally by heat."

In the Journal of the Department of Agriculture of South Africa for March, 1926, the statement was made that *Aphelinus mali* was found abundantly attacking the woolly aphid in the Orange Free State. This was considered remarkable as the parasite had apparently never been introduced into that region.

In June, 1928, Mr. F. W. Pettey of South Africa called at the Bureau of Entomology in Washington, and stated that the *Aphelinus* had had its ups and downs in the Cape State; that it still exists there and is frequently abundant and again nearly absent. The root form of the woolly aphid occurs there as well as the above-ground form. He said that at a higher elevation in a certain orchard the parasite is claimed by a certain fruit-grower to do excellent work. Farther up country a certain owner of a large apple orchard told him that the parasite was doing good work, but on further inquiry the fruit-grower admitted that he was spraying one or more times with nicotine solution.

In a letter received the end of July, 1928, Professor Lounsbury reviewed the situation in the following words:

The insect was quickly and widely established by the material sent by Lundie. My impression is I reared about 11,000 adults from it and the emergences were in early summer when the opportunities were at the best. The rapidity with which the insect spread itself about the country was truly amazing. It was soon found scores of miles from where any were known to have been liberated, and I have come across it in house gardens on lonely stock farms separated by miles of open grass veld from other gardens—owners knowing nothing about it or even the host and hence deliberate introduction being quite improbable. However, it has not, so far as I know, become established in the warmer parts of Natal (I have found it in northern Natal, but in high country); and it does not seem able to maintain itself in the Cape Peninsula nor, according to what R. W. E. Tucker, formerly entomologist at Capetown, has told me, in some other localities in the southwestern districts of the Cape Province. Perhaps an absence of frost is unfavor-

able to it. It thrives very well here at Pretoria, but we have a little frost, although we can grow poinsettia and hibiscus in the warmer parts of our home gardens. I fancy that in the warmer parts few survive the winter owing to emergence during that season. Towards winter here it is common to see apple trees studded with thousands and thousands of parasitized woolly aphids, but by the time the trees begin to burst their buds very few parasites remain. I have found adults on the trees in all the winter months.

Personally I am not at all sure the insect is of much importance. It certainly makes a great showing after about Christmas, but its host gets weeks ahead of it before that and I would expect a very heavy mortality from heat amongst the aphids soon afterwards were the parasite not present. The woolly aphid varies greatly in prevalence from year to year, but taking several years together it seems to me the insect is in as much evidence as before the introduction of the parasite. However, some orchardists think the parasite of great benefit.

Before making his original sendings from Ithaca, New York, to South Africa, Mr. Lundie made a careful study of both host and parasite at Ithaca, and his results were published eventually in August, 1924, as Memoir no. 79 of the Cornell University Agricultural Experiment Station. In his historical review he brings out the interesting point that *Aphelinus varicornis*, described by Girault in 1909 as parasitic upon *Schizoneura crataegi* in Illinois, is undoubtedly a synonym of *Aphelinus mali*. Mr. Lundie made careful studies of the life history of *A. mali*, and describes and figures egg, larva, pupa and adult. He found that at Ithaca the total life cycle from egg to adult extends from 20 to 25 days and that the larval stage occupies from 10 to 12 days. The attachment of the parasitized aphids to bark, noted elsewhere, is according to Lundie due to a liquid that evidently oozes through part of the body while in contact with the twig or other parasitized aphid, and hardens, thus attaching the aphid firmly.

He found that the adult females lived from 11 to 39 days and that they deposited from 48 to 140 eggs each. Parthenogenesis was observed, but abundant males were also found. Hibernation occurred in the full grown larval stage within the body of the host. The interesting statement is made that the aphid undoubtedly continues to produce young during the three days that the parasite egg takes to hatch, and probably also until the larva is about half grown, making in the summer about 7 to 8 days during which the parasitized aphid can still produce young. What is probably a secondary parasite was reared and proved to be the Mymarid *Asaphes americana*.

SPAIN.

The introduction of the parasite into Spain was not attempted until quite recently. Director Jaime Nonell Comas, of the Phytopathological Station at Barcelona, reported in 1926 that in June of that year colonies of *Aphelinus mali* were imported from Italy and Uruguay. The initial work of acclimatization was done in the insectary, and later generations were multiplied in the open field in Alella where a collapsible cage was put up. By September the results had far exceeded all expectations.

In the report of the work done by the Stations of Agricultural Phytopathology and Agricultural Entomology in Spain for the year 1927, published in December of that year, is the statement that the acclimatization and distribution of the *Aphelinus* had proceeded satisfactorily. Incidentally the statement is made that a five-per-cent solution of methylated spirits gave good results experimentally against the woolly aphis. The breeding and distribution seem to have been done mainly at the Barcelona station under the director, Don Jaime Nonell. Colonies were sent mainly to various provinces in the north and east of Spain.

SWITZERLAND.

From Italy there were sent to Gries, near Bozen, Switzerland, some parasitized aphids from which parasites emerged in September, 1923, and on the 10th of October the parasites were clearly established in colonies of the woolly aphis and emerged on the 27th of October. We have seen no report as to whether they successfully passed the winter of 1923-24.

An excellent little paper by Dr. H. Faes, Chief of the Federal Experimental Viticultural Station at Lausanne, deals briefly with the history of the transportation of beneficial parasites from one country to another, and treats especially of *Aphelinus mali*. Originally imported from France in 1922 and later from Italy, it has been reared consecutively in the federal Domain of Pully. He is not yet able to announce definite results, and defers final judgment for some years of different meteorological conditions. He thinks it probable that it may completely destroy the woolly aphis, and feels sure that it will at the least render an important service by reducing the numbers of the pest.

URUGUAY.

In May, 1912, Dr. Roberto Sundberg, Director of the Defensa Agrícola of Uruguay, visited Washington, and, speaking of the entomological problems of Uruguay, he mentioned the fact that the woolly aphis was developing into a pest of considerable proportions. Therefore, when in the early summer of 1920 the success of the carriage of *Aphelinus mali* to France had been demonstrated, it was decided to attempt the introduction of the parasite into Uruguay; and in the autumn parasitized woolly aphids were collected in considerable number, in the United States and in December two packages were shipped to Montevideo, the one addressed to Doctor Sundberg and the other to Dr. G. B. Schurman of the Institute of Agronomy in Montevideo. A previous sending to Doctor Sundberg had not been successful.

On the 13th of January, 1921, the packages were received in Uruguay, were opened by Doctor Sundberg and Doctor Schurman and placed in two cages with apple trees heavily infested with woolly aphis. No living parasites were observed at the time. Later, however, abundant material issued, the sexes were distinguished, and very great numbers of adults were found upon the apple trees, and a very great number of aphids were parasitized. Doctor Sundberg wrote, "It is really astonishing in what abundance the *Aphelinus* is multiplying in our midst."

The winter immediately following (corresponding to our summer in the north) was passed successfully, and a permanent establishment was virtually assured. Soon large colonies were sent out to different sections of Uruguay, and in February, 1925, Doctor Sundberg reported that the parasite had become perfectly established in all sections of the country and that it was perfectly safe to say that there was no infestation of the woolly aphis where the auxiliary was not present.

With great liberality, the Defensa Agrícola began early to send colonies of the parasite to other countries. The list furnished me in 1925 shows the following sendings: 1921, to Italy and Argentina; 1922, repeated to the same countries; 1923, to Chile and to Germany; 1924, again to Italy.

The conditions remain the same; the parasite is perfectly established in Uruguay and continues its good work; the woolly aphis seems to be well under control.

THE MOUND-BUILDING ANT, FORMICA EXSECTOIDES F., ASSOCIATED WITH TREE-HOPPERS.

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Since this common mound builder of the Eastern States is very active all through the warm months and puts forth great energy in the building of its large earth nests, it is of interest to inquire into the nature of the food that keeps it going and tides it over the winter in a semitorpid state in which the food eaten in summer seems the basis for continued life. Near Baltimore in the special region elsewhere described this ant feeds upon offall and earthworms, etc. to some slight extent; but its chief food is got from other insects; either directly by capture or finding of living or dead beetles, flies, bees, bugs, and especially the larvæ of Lepidoptera, or indirectly by utilization of the honey-dew given forth by insects that suck the sap from trees. The protein food got from insects seems small in amount as compared with the chief diet of honey-dew which is largely carbohydrate.

To obtain this honey-dew the ants make long and difficult as well as dangerous excursions out of the nest over the earth to trees which they ascend and explore out to ends of twigs and branches; but in this region the ants are not found swarming over all trees; wild cherry, oak, and sassafras are here seldom traversed by the ants, but processions of ants pass to and from the nest mound to the bases of large tulip poplar trees, *Liriodendron tulipifera* and the much smaller and younger black locust trees, *Robinia pseudacacia* up and down the trunks of which processions ascend and descend scattering and assembling on many parts of the vast system of branches and twigs. In the tall tulip trees the ants disappear from sight but in smaller trees they are seen tending an abundant scale insect, apparently *Eulecanium tulipiferae* Cook, as figured by Felt, which, remaining in one spot occasionally opens a dorsal hole from which clear honey-dew drops are taken by the ants all through the summer and on into October when adult and very young scale insects were very abundant. So much excess honey-dew

is voided by these scales that the leaves of underbrush are smeared as with varnish which is sought out and salvaged by the ants, to some extent. The honey-dew collected from these scales on the tulip tree returns to the nests in the ants that are visibly swollen and translucent as they descend the tree and when taken at random from a tree trunk in July those ants going down weighed each 13 milligrams while those going up empty weighed but nine to ten. It is therefore no wonder that some of the largest mounds seem to have flourished through past years upon the honey flow from some large tulip tree, it may be seventy feet in height, although standing thirty-five to even two hundred feet from the mound yet visited by the ants in long processions.

In this region honey-dew from aphids seems a short and negligible source of energy for these ants though elsewhere it may be very important as Pierson states that it was rare that large colonies of aphids attended by this kind of ant were not found near the mounds. The only use of aphids by this ant that we noted was that in May 1926 black aphids were seen attended by ants, eight ants to 30-40 aphids, on shoots of some poplar tree and solitary aphids much smaller than the attendant ant were found underneath the leaves of this poplar tree; also large dark aphids were attended by this ant on vigorous shoots of the black locust, July 23; but later these aphids were deserted by the ants and the aphids did not continue on into September.

Some few ants were also seen to drink liquid directly from the glandular structures on the leaves of young silver poplar shoots May 29, 1927, but this direct vegetable supply of honey-dew was very exceptional.

It is, however, to the young black locust trees that have through some twenty years spread over the old mine dump that the mound ants, advancing through these years into this new source of supply, look for a steady and long season supply of honey-dew presented to them by two sorts of leafhoppers, Membracids; namely the small *Vanduzeeae arquata* Say and the larger *Thelia bimaculata* Fab. which latter was less abundant in 1927 and 1928 than in 1926.

Thelia is known only upon the black locust and in this region *Vanduzeeae* is found only upon the black locust; thus this tree, its two parasites and the ant, form a close association which we emphasize in the present narration.

When the ants first come out of hibernation they seem to find no regular supply of food and content themselves with working to refinish the surface of the mound degraded by winter. After a month or so when the leaves of the locust are but an inch long, it may be May 15th, the ants are seen crowded at the tips of branches as if eating the leaves but it is then that they begin to obtain honey-dew from the newly hatched *Vanduzea* emerging from the eggs laid last fall in the bark, and aggregating near the bases of the fresh leaves. These larvæ passing through moults become adults in June and gradually more and more adults are commingled with the young in mixed colonies on the twigs, through July, August and September, all the time attended by ants even till October 8th.

Apparently here, as at Ithaca, there are four broods of *Vanduzea* that maintain the supply of honey-dew for the ants during this long season. The aggregates, or colonies, of *Vanduzea* are very diverse in make up comprising larvæ of different ages or instars, as well as male and female adults in all proportions and the entire number may be sufficient to attract attention as a dark mass near the bases of leaves or on the leaflets. One colony had thirty females, 10 males and only two larvæ attended by six or seven ants; eight or nine ants may attend twelve adults with eight or nine larvæ, or one ant may attend a single larvæ; there is no fixed relationship of number between the *Vanduzea* and the ant; but larger clusters generally contain many more larvæ which are in the majority and the ants are generally less abundant than the *Vanduzea*.

The *Vanduzea* larvæ are inconspicuous objects adhering closely to the bark of twigs, inactive, but capable of running about to obtain a new spot into which to sink their sucking mouth parts. Such migrations they readily make when stimulated by touch, but when run over by ants they remain inert. The adults with triangular bodies 5 mm. long, 2 wide and 2 deep like the smaller larvæ stand in under the legs of the ant which is 7mm. long and though but 2-3 wide has from its long legs a standing spread of 5 mm.

When roughly touched the adults hop off into space and fly away or else run along the bark, often to the opposite side of the twig. Here again the running of the ant over the adults fails to liberate this hopping-off reflex and the adults as well as

larvæ of all ages stand in place under the actively moving ants. Yet on one occasion in August when all are most active, an ant running along the bark collided violently with a crawling adult with the result that the above reflex cast them both off into the space; suggesting a possible inconvenience to the ant in associating with this tree-hopper!

Whether ants are present or not each *Vanduzea* larva from time to time rears up and emits a clear drop of honey-dew which falls to earth, or upon leaf, or bark, or else is taken directly by the ant. Several times such drops from both adults and larvæ tested with litmus paper gave areas of 2 mm. in diameter in red, indicating acidity, though the taste is sweet.

The number of drops given off varies much with the individual *Vanduzea* and with other factors. But little is got by the ants from the adults as compared with the larvæ, and the adults often smear the drop onto their long folded wings. As late as September 18 when the temperature was 20 degrees centigrade, a recently shed larvæ sucking the bark gave off one drop and then no more for ten minutes, though this same larva an hour before had given off drops at the following rates: 46, 60, 54, 240 seconds; all these drops were at once removed from the larva by the attendant ants. One ant may drink from many *Vanduzea* and several ants may drink from one *Vanduzea*.

While the *Vanduzea* is thus a relatively inert, passive member of the association, the other symbiont, the ant is deeply implicated. When larvæ of *Vanduzea* with ants were carried many miles and placed upon experimental trees the ants continued to attend the larvæ as they migrated to the new sources of sap, remaining with the *Vanduzea* by day and at night standing stretched out over them only retreating under the twig in heavy rain.

Whenever attending the *Vanduzea* the ants are much on the qui vive, rushing to attack all intruders or possible sources of disturbance, even odors, jars, contacts, or near presence of moving objects and for some time they run about over adjacent leaves or twigs before settling down again to their stand or slow progress amongst and over the *Vanduzeas*. Here they spend much time in going over the surfaces of the *Vanduzea* with antennæ and with palps. The vibration of the antennæ many times a second both over the *Vanduzea* and over the

bark near by suggests rather a search for, or appreciation of, stimuli received, as of odor, than actual attempts at stimulating the *Vanduzea* to give forth honey-dew.

Since the time of Linné some ants are known to stimulate the aphids to give forth honey-dew, and Mordwilko found that gentle touches with a needle would stimulate the aphid to give forth 2 to 4 drops quickly. Attempts to thus stimulate *Vanduzea* were long in vain, but in 1928 success was had with *Vanduzea*, with *Thelia* and with certain aphids. It is thus probable that the ant stimulates the *Vanduzea* and thus modifies the rate of output of honey-dew.

Though the ant makes an exception to its general rule of attack upon insects by leaving the *Vanduzea* immune, yet when the *Vanduzea* is dead or even very severely injured it is picked up and carried to the mound, apparently as food.

Ants were seen to attack and destroy the bases of small locust trees though inhabited by colonies of ants and *Vanduzeas* in symbiotic association; yet here the ants not only cut off their supply of honey-dew, but since there was no evidence that the ants ever transported the *Vanduzea* to better quarters or that the *Vanduzea* migrated of themselves down out of such trees, though in the laboratory death of the tree led to some migration of tree hoppers; they also jeopardized the lives of the *Vanduzea* with resulting loss of egg-laying and future broods of honey-dew producers.

The honey-dew taken from the *Vanduzea* ultimately benefits the entire commune since each ant returns to the nest and gives up of its collection to ants encountered. The length of time spent by each individual ant in collecting a sufficiency varies very greatly in different colonies and at times of day and season. In the heat of the day marked ants remained with the *Vanduzea* more than fifteen minutes before descending the tree. But as late as October 2nd, two marked ants remained with fifteen adult *Vanduzea* for two hours. Running finally very precipitously down the branches and trunks of the trees to the earth the replete ants may do one of several things: search over the earth for droppings of honey-dew, and then return to the tree; or may go straight off from the tree toward the nest; covering such a distance as 31 feet in seven minutes and thus rapidly bringing home honey-dew at midday; frequently, however, the replete ants coming down the tree may

go into holes in the earth at the base of the tree and remain for a few minutes, cleaning themselves and their companions and then either reascend the same tree or go off to the nest. Thus is initiated a flow of ants to and from the food trees along wide but definite paths of travel along which the ants run with speed in the heat but with increasing slowness in the evening coolness. Early in August the flow up and down an inch tree, five feet high, was noted as twenty-two up and twenty down, in seventeen minutes, progressing in unequal squads, three up, three down, in the first two minutes, five up, six down, in the next three minutes, three up, one down, in the following two minutes, then nine up and four down in five minutes, and finally two up, and six down in the last five minutes. On a much larger locust, ants went 59 up to 52 down in five minutes about 7 p. m. September 7th.

Delivered thus from the bases of locust trees ants loaded with honey-dew advance over the earth to the nest, ninety feet in one measured case. The ants going to and from the trees to the nest ran along their paths so that in five minutes we counted eighty-eight going toward the nest and seventy-eight from the nest, in August, or later, in September, at dusk 78 towards and only forty-five from the nest, or later at eight p. m. with increasing cool and darkness, only forty toward and but fourteen from the nest; yet this diminution in flow as day passes into night was not regular and progressive since three minutes after that last record showed 22 toward and 21 outward bound; however with the oncoming of darkness, records were unreliable since the use of searchlight drew the ants aside from the path and thus upset the normal flow along the path. On this same path sometimes but six ants went out at sundown. When the night was warm some few ants went forth and returned at all hours running but slowly; and many remained attending the *Vanduzea* for long periods. *Vanduzea* in colonies at ends of branches receive more continued attendance from ants while *Vanduzea* along the line of march may be the more visited by passing ants.

Turning now to the association of these ants with the large tree-hopper, *Thelia*, we find the same general facts as above described for *Vanduzea* with some added features arising from the fact that this tree-hopper, as found out by Funkhouser in his elaborate study of its life history, deposits its eggs under

ground in the bark of the base of the tree. With large dorsal hump the quaint adults measuring 13 mm. in length, 10 in total height and 5 in width are much more bulky than the attendant ants which are about half as long. Characteristically they stand long in one spot on the bark (some marked adults did not move from 3:30 to 5:15 p. m., October 8) but readily sidle about the stem or leap off and fly away; but if fallen on the earth upside down find the hump on the back a serious obstacle to recovery.

The larvæ passing through five instars from 2 to 10 mm. herd together like *Vanduzeas* and may be commingled with them, various instars mingled, but the larger instars are often concealed in crevices of the bark of larger trees. Their presence, as others have noted, is often first revealed by the motions of the attendant ants, since the larvæ are inconspicuous and long remain in the same spot loath to move without strong stimulation. Two larvæ in the fifth stage remained 40 hours unmoved, September 5th and 6th. Under the lens in the direct sun their odd forms, rough surfaces, scintillations of purple, blue and green, with many golden setæ, make them more attractive than the adults. The honey-dew from the third instar was found to be acid, as in *Vanduzaea*.

The period of their activity as purveyors of honey-dew to the ants is a long one and continues late; May 22nd they were found in the second instar at the bases of a small locust tree within the ant-made tented "succursals" illustrated below. May 29th many of these second instars were three feet up the tree attended by ants.

During June larvæ were found spread over the branches, but in July, August and September much more numerous colonies of *Thelia* larvæ abounded on the stems and branches, sucking sap from near the bases of leaves and also from old wood where cracks in the bark or wound healing offered advantages. On different dates the numbers found varied; apparently there were several broods growing up to scatter somewhat as adults. The young that escape from succursals move upward; in mid August sixty larvæ in first, second and third instars, attended by only one ant, were nine feet above the earth; the youngest must have made their way up in the week since they were hatched below ground. When cornstarch was scattered on larvæ the whole group migrated some 40 mm.

up to a new leaf base. The response of the larvæ to rough touch is like that of the adults; but not being able to fly they fall off to the earth, inactive, for a time; they may then best be gathered up by presenting them with some small object to which they cling.

As in *Vanduzea* there is no fixed proportion between the numbers of larvæ and of attendant ants. Forty larvæ were attended by twenty-five ants, sixty had only one or two ants; but after August rains that may wash them off one group contained four *Thelia*, one *Vanduzea*, and one ant, another two *Vanduzea*, three *Thelia*, and one ant. Generally the more larvæ the more ants attend. While all larval stages yield much honey-dew, the adults supply but little, putting drops on the bark or letting the ants drink it directly from the body, and they tend to finally separate from the ants which no longer evince interest in them and then they form the well known clusters of males and females standing faced one way along the twig; thus thirteen adults stood on three inches of branch, only one being female, at a period when adults in copula were observed. While the females are larger and dull brown, the males are striking as presenting a wide yellow band, but in one case a melanic male was black with white band.

With temperatures of 16 C., October 8th, both adults and larvæ were still on some of the locust trees though most of the ants had withdrawn under ground and only on sunny mounds were there active ants that could still obtain honey-dew from these *Thelias* that thus supplied food up to the end of the ant's season of activity.

The succursals above referred to seem to base upon two potent tendencies of these ants, that to cover up many objects with debris and that to dig holes in the earth. Some ants, especially in the tropics, are known to cover over the insects that yield honey-dew, but Wheeler has described covers, or tents, made of earth or of carton an inch in length made by small ants over coccids and over *Vanduzea arquata* in the northern United States. That *Formica exsectoides* may have such tendency is perhaps indicated by the observation that these ants carried some grains of earth up the trees and deposited them near the *Thelia* larvæ and that one ant was carrying a large stone two feet up a tree, but the stone was then dropped and no actual covers were made up in the trees. The digging

habit is deeply rooted in this ant, each mound starts as a series of vertical shafts and the excavating work is never brought to an end as long as the ants remain. New mounds may be made near old ones or remote from them by few ants starting new excavations. In one case observed June 30 to July 23 a large number migrated out from an old mound, which, however, still remains populous, and dug many holes forty-five feet from the old mound carrying adults, clusters of eggs and young to the new mound that there arose and continued on successfully in following years, apparently quite without any further connection with the mother mound.

Along the line of migration some groups of idle ants seemed suddenly seized with the furor of digging, 20-30 feet from any mound and 6-8 from any food-tree, soon excavating a small well or succursal one-half inch deep and some five days later a small group scrambled over one another to dig such a hole close to the line of march but some fourteen feet short of the arising mound. In the start the ants kick away the loose surface sand, nervously, then begin work with mandibles, pulling off pellets that are carried a little aside and dropped; others crowding in pull the first ant out of the little cup it is digging, rootlets are tugged at; one would suppose there were buried young sought after by the ants; but gradually fewer ants work; the hole becomes more than an inch deep and in three hours is abandoned and not used. The operation seemed an abortive effort at nest beginning. Scattered over this region amongst weeds and brush are many holes in the earth, one quarter to one inch wide and going down as far as four and a half inches; only occasionally with an ant in them such holes seem to be of no use and may be due to such outburst of nest making abilities, for though looking like wasp's burrows they seem undoubtedly the work of this ant.

In addition to these slight excavations there are real succursals at the bottoms of food trees. A tulip tree 40 feet high and 35 feet from a home mound showed ants ascending and descending as well as going and coming over the surface of the earth from mound to tree; other tulips 100 to 200 feet from mound showed holes in the earth at their bases. At the base of the tree several holes led down into the earth and many ants from the tree went into these holes, but the holes did not connect with the mound though they may branch somewhat

under ground and the ants that enter ultimately run to the mound along the surface of the earth. Attempts to find, by digging, any underground connection between trees and mounds were failures though there are areas where the ground is traversed with tunnels and there are tunnels starting out from the base of the mound.* When these succursal holes at the base of a tulip tree were dug away the ants came down the tree into the large excavation thus made and thence out over the earth to the mound passing back and forth without the aid of the succursal.

The use of succursals was more evident in the case of small locust trees up to 6 inches in diameter. Here again the ants often went down into the holes they had dug at the base of the tree but when the earth was removed the tunnels of the ants were found to have blind ends and not to extend far. The ants soon went back and forth over the cleared area made by the removal of the earth, needing no cover at the base of the tree as a necessary part of collecting honey-dew and carrying it to the mound day after day. Some of the locust trees an inch or so in diameter and six feet high had cavities about their bases such as indicated in Figure 1. Here the pit about the tree was partly blocked by rubbish at a depth of two inches and then continued as a narrower passage two inches deep. In cases in which excavated soil had all been carried away by the ants it seemed possible that the tree swaying in the wind might have made such holes about itself. But many of these holes at the base of the trees had side tunnels, some only an inch long and ending blindly and in these ants were found resting, concealed in general, though from some aspects, a lens revealed them. Such ants within the succursal may stand inactive, it may be seven minutes, before they emerge from the succursal and there may be several ants together or only one solitary ant. In the former case, it was observed that the ants clean one another and apparently interchange food at the mouth. Single ants rest and clean themselves.

Ants that built a large mound in the laboratory when allowed access to a flower pot of earth and sawdust with living locust tree, dug holes at the base and used them as succursals, but

*These observations suggest that these succursals misled McCook into the inference that these ants have underground passageways from mound to feeding trees; but these he actually failed to find. *Trans. Am. Ent. Soc.*, 6 1877.

they also dug at the edges of the pot where vertical and horizontal met. Watching in the open the ants on the tree trunks with succursals, it seemed that some on descending after attending the *Thelias* went direct to the mound, others searched about on the earth, while some entered the succursal first. Also ants coming from the mound entered the succursal or else went straight up the tree, one even using an inclined straw to cut short the distance over the succursal. Then marking ants with white or with red paint, we observed, after the excitement of the painting, these ants resumed attendance upon the membracids but finally went down the tree to the

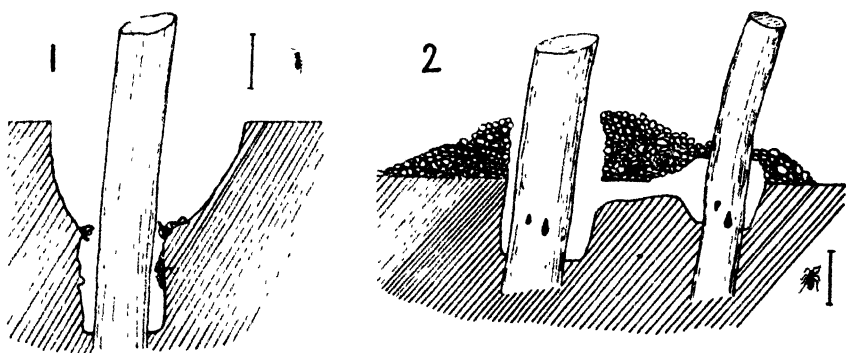


Fig. 1. Succursal dug by *Formica exsectoides* about the base of a young locust tree.

Fig. 2. Succursals of *Formica exsectoides* about the bases of young locust trees. These are connected by a tunnel and protect young *Thelia bimaculata*.

base. Here some entered the succursal and after rest returned again up the tree or emerged on the earth where they either searched about for honey-dew dropped from above or proceeded directly away toward the home mound. Also ants coming from the mound went directly up the tree or else first entered the succursal to remain for a while. There was then opportunity for empty ants from the nest to receive honey-dew from repletes from the tree; but this was not observed.

Among the young locust trees spreading over barren iron sand a most striking fact was the occurrence of small mounds of earth and gravel at the base of many trees on which ants tended membracids. These striking little mounds remained through July and August but later were washed away by rains. As indicated in Figures 2-5, these little mounds are collections of stones, leaves, sticks and earth just as are the mounds used

as nest but each mound is small and has no reference to breeding though it is found to be a temporary branch house within which ants pass some time and also obtain food. These little mounds are essentially roofed-in succursal excavations over which collected material from the neighborhood is piled up so that they have all the architectural elements of the home mound save only the complexities of the internal structure. Figure 2 gives a sectional view of one mound built about two adjacent small locust trees. The earth is excavated about each tree and a tunnel connects both excavations as one cavity, closed in part above by collections of stones, etc. This mound had dimensions of two by three inches and height of from 1 to $1\frac{1}{2}$ inches. The cavity about the smaller tree was nearly closed above but with some space for ant exits while the larger cavity had four definite exits for ants above where the gravel was not in contact with the tree. The heaped up material weighed $2\frac{1}{2}$ ounces or 146.5 grams with a bulk of 100 c.c. Most all was stones, up to 4 by 6 mm. and 5 by 7 mm., many 3 by 4 mm. There was some vegetable matter, bits of dead leaf and sticks, several flat seeds; some few hundred sticks and leaves. Spread out on paper over 35 cm. square, the mass was estimated as 12250 stones with pellets of earth now broken down as sand, bringing the total number of objects piled up by the ants as about 20,000. Ants were found down in these cavities and when the tree was disturbed a dozen, twenty or up to seventy-five rushed out up the stem through the several exits and attacked any new object accessible. Moreover, in all the early summer *Thelia* larvæ were found on the stems of these trees under ground within the cavities excavated by the ants.

In the above mound, Figure 2, about twelve *Thelieas* were on the two trees sucking from the bark, head up or down on the bark as suggested by the black triangular spots in the figure. These young were of two sizes, $\frac{1}{8}$ and $\frac{1}{4}$ inch corresponding to stages or instars, three and four of the five given by Funkhouser as occurring during a month of larval life. Other larvæ were several feet up the tree, July 11, and these like those underground were attended by the ants. One ant up the tree seized a fourth instar and carried it inert, lifted up bodily by the back, downwards toward the succursal, but one leg of the larva catching in the bark, the ant pulled hard and finally changed direction, ultimately dropping the larva a foot and a

half to the ground. The pile of stones having been removed, the larval *Thelia* fell into the succursal, while the ant ran about on the tree as if searching. In capture bottle ants may carry the larval *Thelias* about as if they were ant young. In another case, a *Thelia* larva, disturbed in one of the mounded succursals ran up the tree trunk seven inches while an ant, dragged at it, trying to bite it, apparently irrigating it with the acid. The larva put out its abdominal extension and let honey-dew drop several times. The last drop, falling on bark, was licked up by the ant while the larva escaped and ran up the tree. These were the only observations indicating attempts of the ant to restrain or control the *Thelias* and the small number of *Thelias* found under ground compared to the larger numbers of ants is not in favor of the view that the ants assemble the *Thelias* in

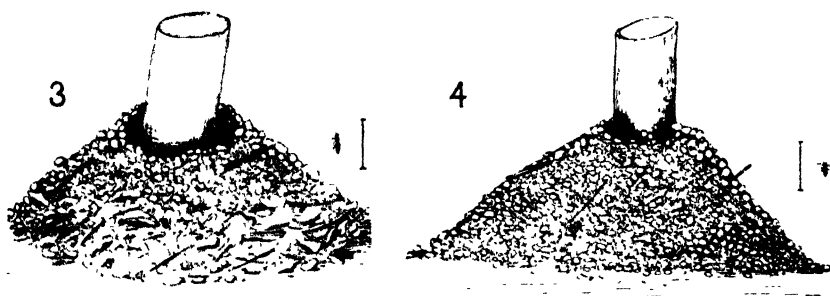


Fig. 3. Succursal of *Formica exsectoides* about base of young locust; composed of leaf-trash as well as of small stones.

Fig. 4. Succursal of *Formica exsectoides* composed of stones and earth the type found on bare ground.

the house they have built, though they do roof over the excavation in the case that there are *Thelias* within it. Even 17 days after the removal of the material of the mound (Fig. 2) the ants had not reconstructed it though they had kept the succursal free from rubbish and a dozen or more stood active in defense of the open succursal.

These little mounds about food trees were rather uniform over the region of bare soil, but in more wooded areas were but faintly represented by slight heapings up of dead leaves and vegetable matter blocking the entrance to the succursals when *Thelias* were to be found sucking from the bark a few inches beneath the surface. The conspicuous mounds were made up as in Figure 3, partly of leaves, or, as in Figure 4, almost entirely

of stones, moreover the entrance was either a complete circular one all about the tree or several openings between which the piled up material touched the bark of the tree. In all cases the exits were at the top and not at the base as in a real incubation mound.

These mounded succursals are made in the early part of the season when *Thelia* larvæ are down in the earth; as time advances, the material becomes compacted by rains and seedlings begin to grow, as in Figure 5, increasing the resemblance to miniature mounds, though they have nothing to do with breeding which is the prime use of the nest mound. It is only in these exceptional regions of bare soil that these tented succursals are such striking objects; elsewhere, in the thicker growths of trees with forest litter, the succursal covers of vegetable matter escape notice and have apparently been overlooked in literature of ants. They were found well kept up as late as July 28, but when roofs were taken off they were not renewed. Though the roofs be finally destroyed by weather, the ants continue to use the succursals even in October with temperatures of 10 C., when some sluggish ants were cleaning themselves and one another in the succursal, while others attended the *Vanduzea*, and yet others were creeping slowly home at 5:50 P. M.

While membracids belong above ground, their presence underground was observed by E. D. Ball in 1915 (4), for he found *Vanduzea vestita* Godg. living exposed to the air upon plants in the Mississippi Valley, but in arid Colorado clustered near to, or several inches under ground on the stems of *Amorpha*, the lead plant, and of *Campelinchia curvata* Fabr. Ball gives a figure of a stem running down as a root under a stone on a mountain slope in Colorado, with *Vanduzea* on the stem and the root under ground. However, the earth was absent from about the stem and over the main root where the *Vanduzeas* stood, so that they were in an air chamber opening up freely to the surface much as in our Figure 2. Such cavities, he says, extended several inches down and occasionally had lateral galleries. That these cavities were really succursals dug out by ants seems certain, but Ball says he did not know whether the excavations "have been made for them by the ants or may have existed previously."

There is thus an association of ants with membracids even in some of the succursals as well as upon the branches where the membracids usually feed. That the ants bring the membracids into the succursals or that they force them to remain there is conjectural. In the case of *Thelia binaculata* Fabr., that lives only upon the black locust, *Robinia pseudacacia* L., accepting the statements of Funkhouser that the eggs are laid only underground, it may well be that the young find themselves underground and remain sucking there till they gradually migrate up the stem. The arching over of the tent roof made

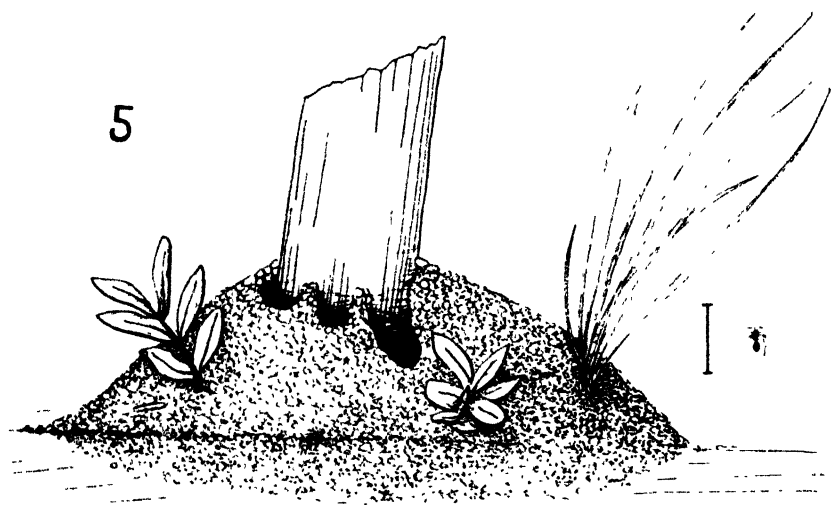


Fig. 5 Succursal in late season, compacted and with vegetation beginning to appear on its surface.

by the ants and their passing back and forth would tend to limit the free upward passage of the young *Thelias* and the observations made above might indicate that the ants do sometimes restrain the migration of the young. Obviously the young are well protected if they are inside a succursal used by a dozen or more of these ants. Another advantage to the membracid will be the presence of the succursal as a means for the adult getting access to the underground part of the stem for oviposition. Where the forest litter is very loose it may be that the adult *Thelia* can force its way unaided down several inches to lay just above the roots, as discovered by Funkhouser, but it would be a gain if the *Thelias* found

openings made by the ants. The adult *Thelia* with its high punchinello spine and small legs seems ill made to force itself into the earth and in the hard subsoil where the tented succursals were found it seems absolutely necessary that the *Thelia* should have some hole made for it, as by the swaying of the young tree or by digging of the ants. The old succursals more or less abandoned by the ants in the later season would be most useful for the *Thelias* to gain access to the underground bark and from this point of view there seems foreshadowed a possible dependence of the *Thelia* upon ants.

That ants get honey-dew from membracids is well known since Belt (7) in 1874 pointed out that in the tropics membracids and coccids largely take the place of the aphids of Europe in furnishing honey-dew to ants, and Green (8) in 1900 in Ceylon saw the extrusion by larval *Centrotus* of a long three-jointed caudal tube with crimson tip and white base "immediately upon application by the attendant ant," and Lamborn (9) in 1913 found the membracid, *Leptocantrus altifrons* Walker in Africa "invariably attended by ants" that were extremely partial to the fluid extruding from the pink caudal whip, and Hinston (15) revealed such wonderful associations in India. Even in the north, ants and membracids form associations as shown by Rice (10) in 1893 and Branch (11) in 1913. The former found the membracid *Entylia sinuata* on sunflower leaves, in Pennsylvania, guarded by two species of ants, one or more ants to each colony, preferring these to aphids and herding them together and supervising the process of ecdysis; and the latter in Kansas found the same membracid attended by numerous species of ants supposedly attending to their wants and being repaid by honey-dew.

The association of membracids and ants raises various questions; in attending does the ant do more than protect the membracid or does it so stimulate it as to vary the amount or frequency of honey-dew given off; on the other hand does the presence of the ants make any difference to the membracid other than the protection that may exist? Funkhouser was able to rear the membracids without ants, and found no evidence that the ants herded or assembled the membracids they associated with. In Baltimore these *Thelias* are found on trees in some regions far away from any ant mounds. It is commonly assumed that the ant stimulates the membracid

by strokes with its antennæ, thus inducing the membracid to let down honey-dew when so stimulated. The membracid seems to show no general response to the presence of the ants. We observed that adult *Thelias* overrun by these ants do not fly away as they often do if disturbed, but remain inactive when stroked and bumped against by the ants while the young in all instars remained immobile when ants ran over them and stroked them. On the other hand, the ants are excited by the presence of the young or the adult *Thelias* and remain with them and on the offensive much as with their own young, and ever ready to attack all that come near. The ants draw a sharp line between dead and living *Thelias*, carrying the former intact or mutilated into their mounds, but leaving the latter quite unharmed.

Thelia larvæ when not attended by ants squirted the honey-dew $1\frac{1}{2}$ inches clear from the vertical trunk of tree they stood on; but when the ants were present the drops came slowly forth and were taken into the mouth of the ant or ants from the tip of the larval *Thelia* which had extended its telescoped abdomen, revealing a white tube with black tip crowned with unequal row of colored bristles, which forms a basket in which the small drop may linger till all drunk up by the ants. In a few seconds as many as six drops may thus flow out and this flow may be repeated several times in five minutes as seen in daylight, or by flashlight at 7:30 p. m. as late as September.

To test whether ants actually stimulate *Thelia* to modify the output of honey-dew, the following experiment was made: Larval *Thelias* standing at least two days on a large trunk were first observed when attended by ants and then when ants were kept away by a barrier of vaseline, all precipitous intruders being thrown out. One *Thelia* gave off drops at the following intervals when attended by ants: 1, $6\frac{1}{2}$, $3\frac{1}{2}$, 4, 1, 10, 14, 0, 5, 1, 3, 1, 2, 4, 1, 2 minutes and at the following intervals when left unattended: 15, 4, 11, 19, 7, $12\frac{1}{2}$, $6\frac{1}{2}$, 6, $17\frac{1}{2}$ minutes. The intervals were thus generally shorter when ants were present. In the former case there were seventeen emissions in the hour, with intervals ranging from 0 to 14 minutes and an average of 3. In the latter case there were but ten emissions during an hour and a half at intervals ranging from 19 to four minutes and an average of nearly ten. When the ants took off the honey-dew the number of drops was not determined but

may have been twenty-four to seventy-five in one hour, but when the *Thelia* cast off its drops they were counted as more than 41 during the hour and a half; thus there was no evidence of any increase of number of drops in connection with the presence of ants. Since the observation with ants present was from 11:30 to 12:29 a. m. and that without ants from 3:00 to 4:38 p. m. some difference in rate of honey-discharge might have arisen from differences in time of day; however, two days later, September 9th, another *Thelia* larva was seen to give off drops at the like brief intervals when attended by ants even as late as 4:19 to 4:28 p. m. We may then infer that the rate of honey-dew discharge is hastened by the presence of these ants, the more so as some *Thelia*, when not attended by ants, stood without giving off drops for more than an hour.

With no ants the honey-dew accumulates till forced out by violent effort of the organs of the *Thelia*; but with ants present a more frequent delivery is induced without forced discharge. There may thus be a mutual advantage in this association, the *Thelia* gaining some economy of effort while the ant gains food materials.

While it is assumed the ant stimulates the *Thelia* by stroking it with antennæ this was not proved. Ants approaching *Thelias* may vibrate their palps as if gathering sensory impressions and the movements of the antennæ suggest picking up of impressions rather than attempts to impart stimulus to the *Thelias*; however, since we have induced *Thelias* to give forth drops when touched, the touch of the ants doubtless stimulates the *Thelia* to partial discharge.

As emphasized by Kornhouser, ants frequently stand at the head end of *Thelias* and we see the ants stand for long with mouth close to various parts of the abdomen, not always at the tip whence may come honey-dew and thus something in the surface of the *Thelia* seems to hold the ant pointed at the body of the *Thelia*. One stood at the head and one at the other end for nine minutes as if held by attraction, getting no honey-dew. Ants being content to stand long close to parts of the *Thelia* from which no honey-dew emerges suggests that the ant may be influenced by some emanation of the body. When the *Thelia* move away along the bark the ant may spend much time cleaning off the bark where the *Thelia* had stood an hour or more. This cleaning of the bark might refer to collection of

honey-dew or to collections of *Thelia* skin exudates. Possibly the intense interest shown by ants in the process of ecdysis or skin shedding of *Thelia* nymphs may be due to exudates of the *Thelia* skin. Thus July 16, when forty nymphs were attended by 25 ants near the crotch of a tree and very many ants were constantly passing up and down close by, it was observed that many turned aside a moment from the path to stand near a *Thelia* shedding into a very late instar, but soon passed on only temporarily diverted by some influence from the larva in ecdysis. But some ants remained with the young that emerged light colored and soft. As it emerged an ant went all over it with its palps, especially at the tail end as it left the larval skin. The ants near were much excited; jumping to attack. The ants licked out the inside of the cast skin and left it to flutter in the wind, while the freshly emerged *Thelia* moved through 180 degrees and settled down to bore into the bark while the ants all went away as if no longer attracted to it. This special interest of the ant in the ecdysis and especially in the inside of the cast skin might be due to accumulations of skin exudates left within the case skin, but unlikely due to honey-dew within. Such interest of ants in the shedding process was observed by Miss Branch who stated that *Entylia sinuata* was dependent upon ant care for successful shedding. The association of this ant with membracids is a form of trophobiosis that, we suggest, may base upon a mutual give and take, the supposed secretions of the membracid may stimulate the ant to act toward it somewhat as toward its own young, which as Wheeler has shown in some species yields to the adult in the remarkable process of trophallaxis (14) a return for the care given it.

In the Ithaca region Funkhouser found *Thelias* attended by *Formica obscuriventris* Mayr, *Camponotus pennsylvanicus* De Geer, *Crematogaster lineatus* Say and *Prenolepis imparis* Say as well as by *Formica exsectoides* F.; but in the region we are now considering this last ant was seen to have competition from only a few small ants; however, the ants getting honey-dew from these membracids do not have undisputed monopoly in this region since several sorts of sugar flies frequent the trees to feed on the honey-dew and come into close association with the members of the locust—membracid—ant symbiosis. While five sorts of flies were observed chiefly two were much in evidence, identified by Professor J. M. Aldrich as *Rivellia*

quadrifasciata Macquart and *Callopistromyia annulipes* Macquart. The former is black, smaller than the ant, and holds its wings horizontally extended showing conspicuous black opaque bands alternating with clear. They often go about in twos. They run, fly and jump about nimbly near the clusters of Vanduzeas and Thelias, apparently having good use of their eyes, retiring when an ant comes even an inch away, while the ant seems unaware of their presence, till almost in contact, but though the ant may rush at these flies they merely go a little to one side on same or other twig and await the opportunity to return, but they may go backward when the ant approaches. They run about nervously and sneak up when no ant is present; in form of body and quick nervous action they are somewhat ant-like. With quick, jerky motions they approach the small Thelia and actually drum on the rear body with their front legs, seemingly striking the larva more rapidly than the ants vibrate their antennæ and then with stout hairy proboscis lick off the honey-dew that the Thelia emits and then sit near by on leaves or twigs to later repeat the operation. These flies were seen earliest in the season, May 19, 1927, at Homewood when the locust leaves were four inches long and as yet no ants nor honey-dew were observable. May 30 the ants there were driving these flies away from the Vanduzeas placed on the locust trees. Later in the summer these flies frequented trees with Vanduzeas and Thelias in various localities. In early September the flies were examining top and bottom of leaves of locust, near a group of some fifty Vanduzeas, chiefly adults with 16 ants on a locust branch 6 feet above ground. They were also seen on the earth as if searching for dropped honey-dew near the base of trees. Even as late as October 2 these flies were near groups of Vanduzeas.

The second common fly, *Callopistromyia annulipes* was observed about the ant-vanduzea-thelia groups on the locust from late May to early October. This fly is much smaller than the house fly but grey with stout abdomen suddenly tapered posteriorly and with wings finely peppered and so held up transversely when walking about that the two wings seem one orbicula sail across the body, a spot on each wing adjoining its fellow to make one central bull's eye in the rounded sail. This fly seems ever searching for honey-dew which it may lick off from the leaf or bark. The fly walks about near the posterior

ends of Thelias and seems to brush against them without making any movement of the legs to stimulate them. In fact its food seems to be merely the drops that are cast off onto bark, etc. and not taken by the ants. The fly with its red eyes seems to see the ant one-fourth of an inch away and quickly flies off or else runs along the branch and when followed by man may dodge around to opposite face of the tree like a membracid. However, the fly is ever returning to the same colony of membracids, flying but a few inches and soon going directly back again, if no ants are on hand. When the ant approaches the fly quickly leaves whatever it is eating. When eating the wings of the fly are folded down horizontally over the abdomen, and seem, then, rather truncated.

A third kind of fly has the same ability to quickly return an inch or two when driven off from *Vanduzea* by the approach of ants. This, like *Rivellia*, actually drums five or six times a second, or faster, with its black front legs palpating the *Vanduzea* adult and larvæ, but with no observed result. Found in September, this fly has big head, reddish eyes, flat empty abdomen, clear wings longer than abdomen, carried folded horizontally over abdomen, and is about the size of adult *vanduzea* female but less thick. A fourth kind of fly apparently in competition with the ants was found recently emerged on the earth as well as perfectly developed in early September. The black metallic body supports wings held down on sides of abdomen with white cross band near the tip; though coming near the *Vanduzecas* it was not seen to get honey-dew with its large proboscis.

SUMMARY.

1. *Formica exsectoides* F. gets food from living and dead insects and from honey-dew that in the region studied near Baltimore is excreted not only by aphids but by coccids and by membracids.

2. In this region this ant forms food getting associations with *Eulecanium tulipiferum* Cook on *Liriodendron tulipifera* and with *Vanduzea aquata* Say and *Thelia bimaculata* Fab. on *Robinia pseudacacia* L.

3. *Vanduzea* and *Thelia* supply honey-dew to the ants chiefly when young, the former with the opening of leaves in

May on through successive broods into October and the latter from late May into October.

4. When no honey-dew is got in March and in November some ants of a colony still labor at the mound, repairing it on emerging from hibernation and improving the roof as last effort in autumn.

5. The membracids are not stimulated by the ants to move about but seem remarkably inert to their presence.

6. Membracids injured or dead are carried off by ants as food.

7. The membracids make no exertion to gain attentions of the ants, in fact may live where no ants attend, but the ants associating with membracids must make long and perilous journeys exposed outside the mound on earth and trees.

8. Ants attend the membracids day and night, individuals taking turns as others fill and return to the mound.

9. When ants are not in attendance the membracids cast off the honey-dew with force, but influenced by the ants, it is discharged with less effort, the culmination of the entire sequence being omitted.

10. The ant explores the surface of the membracids with antennæ and palps as if gaining chemical stimuli rather than stimulating the membracids, yet observations indicate that the rate of flow of honey-dew from a *Thelia* nymph is increased in rapidity when ants are attending; attempts to artificially stimulate the *Thelias* and *Vanduzeas* to give out honey-dew by rapid gentle strokes were successful.

11. It is suggested that the primary influence of membracid upon the ant is through some sort of skin exudation.

12. Succursals made by these ants at bases of small trees when used by *Thelias* are roofed over by the ants as tents that protect and to some extent limit the freedom of the young *Thelias* for a time.

13. The construction of these tented succursals for temporary association of ant and *Thelia* young involves large expenditures of energy in the collection of materials.

14. The honey-dew secreted by these membracids gives acid reactions.

15. In the association of ant and membracid, the former gains a chief food supply; the latter gains protection, and relief

from greater effort. Thelia also gains from the ants advantages of succursal in which to lay eggs underground.

16. While the ants attempt to maintain a monopoly of this honey-dew, there are several sorts of sugar flies associated with the ants and membracids.

17. Some of these flies, as *Callopistromyia annulipes* Macquart merely lick up the honey-dew that has fallen and not been collected by the ants but others, as *Rivellia quadri-fasciata* Macquart, drum very rapidly with front legs before taking off honey-dew from the Thelia larvæ.

18. The flies avoid the attendant ants that are keen to drive off the flies.

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THE BROOKLYN AND NEW YORK ENTOMOLOGICAL SOCIETIES, PAST AND PRESENT.

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An association of twenty-eight years with the Brooklyn Entomological Society and nearly as long with the New York Entomological Society may seem sufficient to establish ones rank to seniority and yet in the light of preceding events, this time really represents only the second chapter of entomological organization in the Metropolis of America. Of the leaders, the workers and the fighters of the first chapter, it has been my privilege to know personally only a few. When I joined the Brooklyn Entomological Society in 1900, most of them had passed away or were comparatively inactive. For the historical part of my report, consequently, I must rely in the main on what has been recorded by older members, principally by Charles W. Leng, the historian of both Societies.

Our earliest local developments among insect collectors are related by E. L. Graef in a paper on "Some Early Brooklyn Entomologists" published in the Bulletin Vol. 9, No. 3. He and two schoolfellows, Frederick Tepper and Augustus Radclyffe Grote began the making of collections in 1854. Not knowing anything about cyanide bottles and preservatives and with no literature excepting a copy of Emmons "Insects of New York State" contained in the small library of the Graham Institute, predecessor of the Brooklyn Institute of Arts and Sciences, these lads nevertheless struggled along persistently, eager for information and meeting in turn John Ackhurst, Stephen H. Calverly, Herman Strecker, J. A. Lintner, John G. Morris, W. V. Andrews and Henry Edwards, all men recognized then or later for their work in entomology.

The outstanding event in the entomological career of Mr. Graef was his meeting in 1870 of Prof. Franz G. Schaupp, justly called the father of the Brooklyn Entomological Society. Quoting the words of Graef "He was of middle age, of very large proportions, weighing perhaps 250 pounds, with a massive head crowned with curly hair, well tinged with gray. The hat which he wore would fall around the ears of any person I have

ever met. It measured No. 8. He was pleasant, cordial and overflowing with good nature and humor. We soon became greatly interested in each other and in insects. Of course, we had to partake of a number of beers and he insisted on my accompanying him the next day to what was then known as the Eastern District, which place, he stated, fairly swarmed with entomologists, some in embryo and all of whom he desired should know me. So the next day we sallied forth and I was duly introduced to everybody in the neighborhood who had a collection, even if it were only in a saloon where the proprietor had a framed case of "flies" hung behind the bar. As a *sine qua non* we had a complement of beers and I may be pardoned if I cannot distinctly recollect all the distinguished entomologists whose acquaintance I made on that memorable occasion. So much enthusiasm was created, however, that Prof. Schaupp and I suggested that we ought to meet regularly and form some sort of an association. Accordingly a meeting was called at Schaupp's rooms, on the top floor over Schaeffer's saloon at 9 Broadway, Brooklyn. This was well attended and resulted in the formation of the Brooklyn Entomological Society. Schaupp was the first President and I the first Treasurer."

Presumably after this informal organization, meetings were continued, but whether at regular or irregular intervals there are no minutes to tell. Most likely the meetings at first were more in the nature of social gatherings at which refreshments, especially liquid, played an important part. From Leng's "Memories of Fifty Years Ago" in the *Bulletin* Vol. 18 No. 1 we learn that when as a boy of 16 he joined the Brooklyn Entomological Society in 1875 or 1876 its prominent members were Graef, Tepper, Fuchs, Luetgens and Schaupp, the latter the most prominent of all. Leng's accounts of Schaupp and other pioneers are delightful and his sketches of the proceedings at the meetings most amusing. It is hard to resist the temptation to quote him in full.

An era of unrivalled activity and enthusiasm for the Brooklyn Entomological Society set in with the publication of the *Bulletin*, beginning in May 1878 and appearing monthly at the subscription rate of 50 cents per annum. These rates were increased to 60 cents and later to \$1.00. The volumes running from 100 to 150 pages. The *Bulletin* was managed by a publication committee of five of which Schaupp was the

chairman, as well as the leading spirit as in all matters concerning the Society. His directing influence is unmistakable in the policy and contents of the publication. There are, useful hints for practical collecting, notes on breeding insects, new discoveries and descriptions, synoptic tables of N. A. Coleoptera and Lepidoptera, lists for exchanges; in fact good reading matter for student and layman alike. The Bulletin at once became the popular medium for publishing observations and studies not only by local members but by outstanding entomologists throughout the country as well. A list of contributors to the first volume contains the names, alphabetically arranged, of Dury, Fuchs, Gissler, Graef, Grote, Horn, Hoyt, Hulst, Koebele, Le Conte, Schaupp, Saltzwedel, Schmelter, Strecker, Tepper and Wilson. Schaupp topped the list with twenty papers. Later authors include Blanchard, Hy. Edwards, Meyer, Nostrand, Webster, Bailey, French, Julich, Knauss, John B. Smith, Ulke, Ricksecker, Riley, Holland, E. A. Schwarz, Casey, Cramer, Doll, Leng, Reinecke, Roberts and Willeston, the latter introducing for the first time the subject of Diptera in Volume 7; all previous papers having been devoted exclusively to Coleoptera and Lepidoptera.

The early volumes, we are told, were edited at the meetings of the Society in Schaupp's room and generally under heated discussions, to be continued after adjournment downstairs in Schaeffer's saloon. The Society outgrowing its quarters, meeting places were changed to Wright's Business College and to the Polytechnic Institute. Schaupp's climax of entomological work was attained with the publication of his synoptic treatise of the Cicindellidæ in the Bulletin Vol. 6, November 1883. It contains 81 pages of text, beautifully illustrated with one black and white and four colored plates. Soon after he departed for Texas, a misfortune for the Society and, as it turned out, as well as for himself. Separated from his many friends and co-workers and living in comparative loneliness and poverty he died in 1904.

After Schaupp's departure, John B. Smith, who as a young man of 23 had joined the Society in 1881, took up the reins and we may add, laid the foundation for his subsequent so prominent career. Appended to Vol. 7 of the Bulletin, we find a "Certificate of Incorporation" dated January 13, 1885 and a list of 32 original members, including the following not mentioned before: Angell, Beutenmuller, Duering, Elliot, Frank,

Gade, Linell, Luetgens, Neumoegen, Pearsall, Schenk, Waters and Weeks. The volume concludes with the "Notice to Readers"—"With this number the Bulletin of the Brooklyn Entomological Society ceases to exist. The unanimous expression of the desirability of a union of Entomological Journals into one paper which might call to it the support of all those interested in Entomology, led to negotiations between the representatives of the Bulletin and Papilio resulting in an arrangement for the issuing of a new publication, for which the name "*Entomologica Americana*" has been decided upon. It will be edited by Mr. John B. Smith, and the subscription price will be \$2.00 per annum."

Averaging 240 pages per volume, *Entomologica Americana* was published regularly in monthly numbers beginning April 1885 and ending with Volume 6, December 1890. Among the authors not previously cited are Ashmead, Cook, Davis, Fernald, Henshaw, Howard, Kellicott, Osborn, Wenzel, Bergroth, Chittenden, Fletcher, Schaus, Skinner, Slosson, Van Duzee, Wickham, and Zabriskie. Meanwhile the meetings of the Society were held at the Brooklyn Institute on Washington Street, where its collections and Library also were housed. Attendance at the monthly sessions was 20 to 30 and even 50 to 70 on some occasions. Altogether the Society was in a most flourishing condition when on September 13, 1890 a fire in the Institute building not only deprived it of headquarters, but more or less damaged its property. Added to this came the resignation of John B. Smith as editor in December. The bottom dropped out. The Society went into hibernation not to awaken until ten years later.

With this all too brief outline of the first chapter of the Brooklyn Entomological Society we cross the East River to see what the entomologists have been doing in New York City. On October 3, 1880 we find at the home of B. Neumoegen, 76 West 47 Street A. R. Grote, E. L. Graef, A. Koebele and Hy. Edwards assembled to form an association to be known as the N. Y. Entomological Club. This duly accomplished, the following officers were elected: President, Augustus R. Grote; Treasurer, B. Neumogen; Secretary, Hy Edwards. In the minutes for the first annual meeting held at Mr. Edwards' house on December 11, 1881, we read that ten numbers of the official organ of the Club "*Papilio*" devoted exclusively to Lepidoptera had been published and that 127 members consisting of 19

active, 17 honorary and 91 corresponding members had been enrolled. This looks like good progress, but turning to the treasurer's report we find charged to income from subscriptions and other payments \$194.46 and to disbursements for printing \$415.73, leaving a deficit of \$221.27. This looks not so good. In another entry a motion is passed empowering the secretary to alter and modify Mr. Hulst's letter of rejoinder to Mr. Grote, so as to omit all personalities and that Mr. Hy Edwards be requested to publish in the same number all the evidence in his possession referring to the priority of names of *Catocala* now in dispute between Messrs. Strecker and Grote. This indicates dissension and asperity, a spirit not confined to the Club but rampant generally at that time.

And on the other hand, not before or since, has there been so much rivalry and competition among Entomologists to excel in the possession of large, comprehensive collections. Many bitter combats, mostly, but not always, fair took place. With some, the acquisition of great collections became an obsession. They would rather collect than eat. Now that the battles are over and the warriors at rest, it is a satisfaction to contemplate that the spoils of war have not been wasted. The most prominent of the collections are housed in the Museums of New York and Brooklyn or elsewhere, accessible to investigators at all times. A little of this spirit of competition and combat, leaving out personalities, injected into our present placid and regulated affairs might not be amiss.

Meetings of the N. Y. Entomological Club called for October and December, 1882 show the significant entries "no attendance." *Papilio* ceased with Volume 4, Nov. 1884. To lepidopterists it has been and still is a most valuable publication. Volumes 2 and 3 are exhausted. Volumes 1 and 4 are still available through the Brooklyn Entomological Society.

The next nine or ten years are shrouded in mystery. Not until 1891 we learn from a paper by Chas. W. Leng in the *Journal* Vol. 26 were meetings held again. On June 29, 1892, the N. Y. Entomological Society was organized with Chas. Palm as temporary chairman and Dietz, Beyer, Tunison, Schaeffer, Beutenmuller, Rabe, Neumoegen and Mrs. Annie Trumbull Slosson as members. In September, Ottolengui, Angell, Havell, Meitzen, Seibolt, Bradford and Julich joined the Society. Thereafter meetings were held regularly at the

homes of Palm, Neumoegen, Mrs. Slosson and sometimes at the German American school on East 53 Street until finally, through Mrs. Slosson's intercession with the late Morris K. Jessup, headquarters were established at the American Museum of Natural History under whose conspicuous auspices the Society has met ever since. The incorporation of the Society was effected June 7, 1893. Previous to that the Journal was started by subscription with Mrs. Slosson the largest contributor. Part of the expenses of printing were defrayed from the proceeds of auction sales of insects, Mrs. Slosson again donating most liberally from her collection. These auction sales afforded Mrs. Slosson much amusement. "I should like to attend one now. The movies are nothing compared to them," she remarks in a paper of reminiscences in the Journal Vol. 26. Regarding her attendance at one of the early meetings at Mr. Palm's house, she says, "I shall never forget the sensation produced by my unexpected entrance into that scientific meeting. Through the smoke of pipes and over mugs of some beverage which foamed in the gaslight in a sudsy sort of way I saw startled and embarrassed faces. 'A woman, and finding us like this!' After seating me in the most comfortable chair, good Mr. Palm hastened away to order coffee as more appropriate and fitting drink for a feminine throat. I was not at all shocked at this orgie, for I had five brothers and spent much of my time in a tobacco-smoky atmosphere. After that I attended the meetings quite regularly and came to know very pleasantly most of the members."

Following its incorporation the Society continued successfully for about ten years, meeting twice monthly. Beutenmuller was editor of the Journal, which was published regularly. The average attendance was about eight members with rarely a meeting lacking a quorum. During this period, Joutel, Shoemaker, Love, Lagai, Davis, Barber, Wunder, Camman, Weeks, Comstock, Watson, Green, Leng, Graef, Southwick, Sherman, Engelhardt and Harris became members. The Society also affiliated with the N. Y. Academy of Sciences, whereby the members receive the weekly "Bulletin" announcements of meetings. Social gatherings after the meetings adjourned became also an important feature. Prof. Wheeler who became a member in 1903, and Dr. Lutz who joined soon thereafter by their active participation and versatility added

much to the interest and importance of the meetings. The attendance grew rapidly, many new members were enrolled and a remarkably good feeling among all was the result. The Society's affairs have prospered ever since.

The time limit of my report does not permit me to mention by name all the good members and friends whose service and loyalty have crowned the Society with success. However I must refer to some of the officers, for few Societies have been so fortunate in the selection of men—faithful and untiring in their labor of love. As Presidents served successively: Angell, Beutenmuller, Zabriskie, Palm, Love, Groth, Roberts, Leng, Osburn, Barber, Woodruff, Sherman, Lutz, and our present honored incumbent Henry Bird. As Treasurers: Groth, Joutel, and Davis. As Secretaries: Joutel, Barber and Leng. That in 35 years only three men have served as Secretary and the same number as Treasurer, is exceptional. The maxim here applies—when you have a good man, keep him in office—and that has been done.

Mr. Leng has been Secretary for the past twenty years. His minutes are models of precision and composition. Often I have been surprised at my own eloquence when reading his account of my talk in the minutes.

Mr. Davis has steered the financial affairs of the Society for twenty-five years and there has been rough sailing at times. How he weathered the storms he does not tell. He doesn't have to. We know. Now his ship has arrived in a safe harbor. Our beloved friend and fellow member, the late L. B. Woodruff, in his will bequeathed to the N. Y. Entomological Society the sum of ten thousand dollars to be applied as an endowment to the publication fund. To him we owe a vote of undying gratitude and thanks. The interest of this endowment added to the income from well above one hundred members and about three hundred subscribers to the *Journal*, assures to the N. Y. Entomological Society a future of growing influence "in the advancement of entomology in all its branches."

For the last chapter we retrace our steps to 1900 and after recrossing the East River, find that the Brooklyn Entomological Society has awakened from its hibernation and that a meeting has been called by George Frank, manager of the American Entomological Co., at his office and residence on DeKalb Avenue. About thirty people, old timers and newcomers

assembled. I was one of the newcomers. Among those present, I remember Smith, Graef, Pearsall, Weeks, Doll, Call and Love. The death on that day of Geo. D. Hulst, a charter member, was announced. When after adjournment we partook of the liberally provided liquid and solid refreshments in the basement, I passed muster in the proverbial qualifications expected of an entomologist, his ability to drink beer. These social diversions after adjournment, always have been a special attraction at the Brooklyn meetings. I have yet to meet the member who for reasons of his calling or creed objected to these proceedings. They were always conducted within reasonable limits of enjoyment.

The first publication by the Society after re-organization was the Glossary, an Explanation of Terms used in Entomology, by John B. Smith. It was issued in 1906, cloth bound, 154 pages, three plates on structures and one on colors. Dr. J. W. Folsom, now at the Delta Laboratory, Tallulah, La., contributed substantially to this publication by sending in over 2000 cards of terms collected by himself and his assistants while at Urbana, Ill. The book, 3,000 copies, was financed from the treasury and by subscriptions from members. It was received so favorably that in less than two years all subscriptions had been repaid and it has been a source of income to the Society ever since. A reprint of 1,000 copies in 1920 has again become nearly exhausted. A revised and up-to-date edition is now under consideration.

The re-publication of the Society's official organ, the Bulletin, was not attempted until a removal to the present meeting place at the Brooklyn Museum of Arts and Sciences on Eastern Parkway had been effected. The Bulletin, New Series, appeared again in October 1912, edited by R. P. Dow, whose essays on ancient entomology afforded frequent entertainment at both Societies. When he left for California in 1919, J. R. de la Torre-Bueno became and still is Editor. Steadily increasing support and a list of subscribers, exceeding 300 have made the Bulletin, now in its 23d volume, about self-sustaining. Meanwhile it has more than doubled its contents.

Entomologica Americana, the successor to the Bulletin and *Papilio* in 1885, after a lapse of 36 years, also was revived again in 1926, thanks to the generosity of Wm. T. Nichols, Jr., one of our honorary members. Mr. Nichols' untimely death,

early this year, has meant a severe loss to the Society. This publication is issued quarterly, 50–60 pages to the number or 200–240 pages to the volume at the rate of \$4.00 per annum. It is intended for longer papers—monographs, synopsis of smaller groups, biological studies, morphology, embryology and revisions too long for regular journals and yet too short for a book. For such a journal there has been a long-felt need. Volumes 7 and 8 have been completed. Volume 9, No. 3, is now in press. Our present aim is to get 200 subscribers of which 125 have been booked.

Compared with the N. Y. Society, the Brooklyn Society appears to be forging ahead with its publications. Its annual expenses for printing are now near \$3,000, which has been covered by subscriptions and income from other sources, leaving a safe balance in the treasury. On the other hand, we have not been as successful in the enrollment of members, the list of active members having remained nearly stationary, around 50 for thirty years. Relations between the two Societies are most cordial, many members belonging to both.

As officers for the Brooklyn Society are serving since 1920:

<i>President</i>	WM T. DAVIS
<i>Secretary</i>	ERNEST L. BELL
<i>Treasurer</i>	GEORGE P. ENGELHARDT
<i>Editor since 1919</i>	J. R. DE LA TORRE-BUENO

Teamwork between these officials has been splendid, all doing their very best for the Society.

In the present age of specialization friction among members, formerly so rampant, has disappeared almost entirely. The meetings, informal as always, nevertheless are full of zest and interest. After adjournment at 10 or latest, 11:00 P. M., everybody goes home. Gentle admonitions on part of my family, implied in the question "is this going to be a late session" have ceased long ago. What we miss these days are the get-together times at annual dinners and on field meetings which Newark, Philadelphia and even Washington used to join.

When I meet entomologists on my travels, I am always sure to be received as a friend and in a spirit which lets one feel that we all belong to one big fraternity. In this spirit I close my report with the assurance to one and all that a hearty welcome always awaits you at the meetings of the Brooklyn and New York Entomological Societies.

**THE DETECTION AND ESTIMATION OF INSECT CHITIN;
AND THE IRRELATION OF "CHITINIZATION" TO
HARDNESS AND PIGMENTATION OF THE
CUTICULA OF THE AMERICAN COCKROACH,
PERIPLANETA AMERICANA L.**

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The cuticula and intima of insects have long been known to contain an organic compound remarkable for its insolubility in solutions of potassium hydroxide or sodium hydroxide of any concentration. Through this property it was discovered¹ in the elytra of May beetles by Odier (36) in 1823 and was named chitine (spelled chitin in German and English), by him from *χιτών*, a Greek garment. This substance is well known by name to American entomologists who frequently use the term "chitinous" or "chitinized" in morphological or taxonomic descriptions, but its properties and distribution in insects are still so poorly understood by them that these terms are often misapplied.

The purpose of this paper is to describe methods which have been improved by the writer for the detection and estimation of chitin in insects and to present the results of these methods as applied to the cuticula and intima of the American cockroach and other insects. These results, together with facts from the extensive foreign literature on chitin, will be discussed from the point of view of the entomologist who wants to know what chitin is, where it occurs in insects, and what the relations may be, if any, between pigmentation and hardness and "chitinization" of cuticula. Statements concerning chitin in our entomological text-books which are contrary to fact will be pointed out and corrected.

¹Strictly speaking, it was Bracconot (7) who discovered chitin in 1811. By treating mushrooms with alkali he obtained an insoluble residue containing nitrogen which he called fungine. He said of it (p. 267), "Cette substance de quelques champignons qu'elle provienne, séparée de tout corps étranger par l'eau bouillante aiguillée d'un peu d'alcali, est, plus ou moins blanche, molasse, fade, insipide. . ." But it was not until the end of the century that fungine was proved to be identical with Odier's chitine.

THE PROPERTIES OF CHITIN.

Chitin is a colorless, nitrogenous polysaccharide². Its molecule is composed of an unknown number of acetylglucosamine³ residues, linked through nitrogen, according to Karrer and Smirnoff (21). By X-ray analysis Gonell (15) proved that chitin is microcrystalline and calculated that the elementary body or crystallite, which may or may not be the same as the chemical molecule, is composed of 18 acetylglucosamine residues. The most probable empirical formula, $(C_{32}H_{54}N_4O_{21})_x$, is that of Brach (6).

Chitin is insoluble in water, alcohol, ether, and dilute acids, and in dilute or concentrated alkalis. It is dissolved with or without decomposition by concentrated mineral acids and, according to Schulze and Kunike (44, p. 558), by water-free formic acid. Von Weimarn (51) finds that chitin goes into colloidal solution in solutions of salts, particularly lithium thiocyanate, capable of strong hydration.

Chitin is hydrolyzed by concentrated mineral acids with the formation of a glucosamine salt or chitose, a sugar, and fatty acids, chiefly acetic. It is hydrolyzed by concentrated solutions of potassium hydroxide or sodium hydroxide at high temperatures to form chitosan⁴ and acetic acid without change

²Imms (17, p. 6): "Chitin is related chemically to the cartilage of vertebrates and also to mucin." This statement gives the impression that chitin is a protein, whereas it is essentially a polysaccharide and is related only to the carbohydrate part of glucoproteins from cartilage and mucin.

³Morgulis (34), who has written the only American paper on the constitution of chitin, is the only recent worker who doubts that the acetyl group is a constituent of the chitin molecule. He believes that acetic acid from acid or alkaline hydrolysis of chitin is a secondary decomposition product. The present writer believes that the evidence against Morgulis's view is stronger than that in its favor.

⁴Chitosan was discovered by Rouget (39) in 1859. He found that chitin which had been boiled in a very concentrated potassium-hydroxide solution became soluble in dilute organic acids. This modified chitin, as he called it, was colored violet by dilute solutions of iodine and acid, whereas chitin was stained brown. Modified chitin was not studied again until 1894 when Hoppe-Seyler (16) named it "chitosan." Von Fürth and Russo (14) showed that chitosan behaves chemically like an alkaloid, forming crystallizable salts with acids and being thrown out of acid solution by alkaloid precipitants. Löwy (31) studied the elementary composition and crystalline form of chitosan sulphate, which is one of the most stable and insoluble of the chitosan salts. The solubility of chitosan in dilute acids, its iodine-acid color reaction, and the characteristic properties of chitosan salts, particularly of chitosan sulphate, form the basis of the best modern microchemical tests for chitin.

in appearance⁵. Chitin is oxidized and dissolved at room temperature by a solution of sodium hypochlorite containing 5 per cent available chlorine⁶. Wester (52, p. 293) confirmed the reports of earlier workers that chitin is not attacked by mammalian digestive enzymes⁷. Chitin is broken down by *Bacillus chitinovor* Benecke (3), which may be responsible for its decomposition in nature.

The specific rotatory power of chitin in hydrochloric acid (sp. gr. 1.16) solution is $[\alpha]_D^{20} -14.1^\circ$, Irvine (18); its index of refraction is $1.525 \pm .005$, Becking and Chamberlin (2); and its specific gravity is 1.40, Sollas (46)

A mass of evidence, too great to be detailed here, indicates that chitin has the foregoing chemical and physical properties whether it is obtained from fungi, molluscs, annelids, or arthropods⁸; i. e., there is only one chitin. Possible exceptions to this rule have been reported recently for *Limulus* by Frankel and Jellinek (13), for certain fungi by Dous and Ziegenspeck (10), and for the marine worm *Eunice* by Gonell (15, p. 21).

⁵Imms (17, p. 7) "It [chitin] may be boiled in concentrated alkali for long periods without undergoing decomposition." If by "decomposition" Imms means disintegration, the statement is correct; but if the word has its usual sense of chemical change, the statement is wrong, because chitin may be decomposed under the foregoing conditions into chitosan and acetic acid.

⁶The solubility of chitin in sodium hypochlorite solution was first noted by Looss (30) in 1885, but his observation was discredited by Wester (52, p. 292), who asserted that pure chitin was not affected by this reagent at ordinary temperatures. More recently, Ito (19, p. 364) noted the solubility of chitin in cold sodium hypochlorite solution. The present writer confirmed Ito's observation, using a solution containing 5 per cent available chlorine. Pure chitin disappears rapidly at room temperature with evolution of gas. Natural cuticula is also completely decomposed.

⁷Although no cases of the digestion of chitin, by insects for its utilization as food are yet known, it is certain that some insects are able to dissolve chitin and lay it down again in a new form. The old chitinous endocuticula may practically disappear just before ecdysis. (Plotnikow (38, p. 339), Muller (35, p. 554)). The writer finds that the cast skin of the American cockroach consists almost entirely of exocuticula. Uvarov (Trans. Ent. Soc. London 1923, p. 300) mentions the formation of chitinous cocoon threads by a fungus feeding beetle larva and the softening or solution of the integument of a spider by a hymenopterous larva which consumes the entire body of its host.

⁸The most trustworthy and comprehensive surveys on the distribution of chitin in invertebrates are by Van Wisselingh (55, p. 679-683) and Wester (53); in fungi by Van Wisselingh (55, p. 658-676) and Von Wettstein (54).

A METHOD FOR THE DETECTION OF CHITIN IN INSECTS⁹

A milligram or less of insect cuticula or intima, freed from tissue or food as far as possible, is placed in a 1.9×7.6 cm. ($\frac{3}{4} \times 3$ inch) shell vial containing about 3 cc. of potassium hydroxide solution, saturated at room temperature¹⁰. The vial is closed by a rubber stopper bearing a Bunsen valve¹¹ and is lowered into a beaker containing glycerine. It is supported by a clamp so that the alkali lies below the surface of the glycerine and the vial does not touch the bottom or sides of the beaker. A thermometer is suspended in the glycerine and the bath is heated slowly (in 15 or 20 minutes) to 160° C. By alternately removing and replacing the Bunsen burner, the bath is held at this temperature for 15 minutes. The vial is then allowed to cool to room temperature and the contents are poured out into a watch glass. If the material has dissolved, no chitin was present. If there is insoluble material, it is transferred to 95 per cent alcohol and is passed through 70 per cent, 50 per cent, and 30 per cent alcohol to water, in which it is washed. It is then ready to be tested for chitin on glass slides under a compound microscope.

If the material consists entirely of chitosan, the following reactions occur: A piece of the material dissolves in a drop of 3 per cent acetic acid, from which solution a white precipitate (chitosan sulphate) is obtained by the addition of a drop of 1 per cent sulphuric acid. Another piece if covered by a drop of 0.2 per cent iodine in potassium iodide solution is stained

⁹Since the writer believes that his method is simple enough to be used as a laboratory exercise by students of elementary entomology, details of the method, many of which might be modified, are described without comments or digressions. In the next section reasons for various recommendations will be given and the relative merits of this and other methods will be discussed.

¹⁰Weights of potassium hydroxide and water to be used for the solution vary, of course, with the purity of the former and the average room temperature. But to give an idea of the relative quantities it may be stated that the writer made a stock solution by dissolving 400 grams of 85-88 per cent potassium hydroxide in 250 cc. of water. The solution was stirred and cooled to room temperature and stored in a paraffin lined bottle closed by a rubber stopper. To line a bottle with paraffin, clean, dry, and warm it, and pour into it 58° paraffin a little above its melting point. Place the bottle on its side and roll it back and forth until the walls are evenly coated; then stand it upright and let the rest of the paraffin solidify on the bottom.

¹¹Take 5 centimeters of rubber tubing, force the pointed blade of a pair of scissors through the wall near the center of the piece, and make a $\frac{1}{2}$ cm. slit in the wall, lengthwise of the tube. Attach one end of the tube to a short piece of glass tubing projecting from the rubber stopper. Close the other end with a bit of glass rod. Be sure that the slit is not covered by the glass tube or rod.

brown. This drop is drawn off by a capillary tube¹² and is replaced by a drop of 1 per cent sulphuric acid. Instantly the material assumes a deep reddish violet color where it is thin enough to be translucent. Thicker parts appear black but they will show the violet color after being washed sufficiently in water. The dilute acid or water is replaced by a drop of 75 per cent (by volume) sulphuric acid. The color disappears as the object goes slowly into solution. The slide is set aside upon a watch glass containing water and is covered by another watch glass. When it is examined again after two or three hours or on the next day, the drop appears cloudy. It is washed from the slide by a stream of distilled water and the slide is dried. A cloudy film remains on the spot which the drop occupied. The compound microscope with 4 mm. objective resolves the film into colorless spherical crystals (probably chitosan sulphate) of various diameters not exceeding 20μ and usually much smaller. A drop of a 0.1 per cent aqueous solution of an acid dye, e. g., rose bengal, is placed on the film. The dye, which stains the crystals almost instantly, is washed off the slide by a stream of distilled water. After the slide has dried, a permanent mount of the stained crystals is made in balsam. If the chitin in the object to be tested has been only partially converted to chitosan by alkali treatment, the foregoing reactions will be obtained, except that the object will not dissolve completely in 3 per cent acetic acid.

The only other organic compound known to the writer which might be present with chitosan is cellulose. This may contaminate a chitosan preparation in the form of fibers from lens paper, filter paper, or toweling, or as the remains of plant food in the alimentary tract of insects. It does not dissolve in dilute acetic acid and is not colored by iodine-dilute acid, but swells and turns blue when 75 per cent sulphuric acid is added to decolorize and dissolve the chitosan. Moreover, cellulose does not yield spherical crystals, nor crystals of any kind, under the treatment by which they are formed from chitosan and sulphuric acid. Cellulose is not stained by acid dyes, except, as in the case of congo red, when salts mixed with the acid dyes alter their normal staining reactions.

¹²The writer uses a single pipette for all solutions. It is simply a piece of ordinary 5 mm. glass tubing drawn to a fine tip at one end and attached to a piece of rubber tubing at the other. Mouth pressure or suction on the rubber tube is used to place drops on or remove them from the slide. The pipette is rinsed with water and solution in passing from one solution to another.

DISCUSSION OF METHODS FOR THE DETECTION OF CHITIN.

Preliminary alkali treatment of material suspected of being chitinous serves a threefold purpose: First, complete solution of the material demonstrates the absence of chitin; second, organic substances intimately associated with chitin are usually removed, or at least eliminated to an extent which prevents their interference with subsequent tests for chitin; third, chitin is changed to a more reactive substance, chitosan, on the properties of which are based the most dependable microchemical tests for chitin.

It would be expected from the general effect of temperature and concentration on the rate of chemical reactions that the higher the temperature and the concentration of alkali the more rapidly and completely these results could be obtained. This is borne out by experience in converting chitin to chitosan, although no comprehensive experiments on this point have yet been made. The limiting temperature above which chitosan is completely broken down by alkali is 184° C. according to Hoppe-Seyler (16, p. 3,331). The highest concentration of alkali which might theoretically be used is that from which potassium hydroxide crystallizes out at 180° C. But it is impracticable to use such a high concentration.

Van Wisselingh (55) in 1898 was the first to prepare chitosan especially for microchemical tests. He heated chitinous material in concentrated alkali (a 50 or 60 per cent solution was later recommended) in sealed tubes to 160° C., and at that temperature obtained rapid and complete conversion of chitin to chitosan. The use of sealed tubes instead of open vessels prevented boiling and evaporation of water from the solution and thus avoided possible mechanical injury to delicate material either by its violent movement in a boiling solution or by its inclusion among crystals from the more concentrated cooled solution. This is an excellent method, which usually gives an experienced investigator no trouble, but it is not one to place in the hands of students, because improperly sealed or weak tubes may, and do, explode. The writer has had one explosion and was fortunate in having escaped injury. Partly for this reason and partly for following the line of least resistance, Vouk (50), Spek (47, p. 327), and Schulze (41, p. 389) proposed modifications of Van Wisselingh's method in all of which the

objects were heated in open vessels. Vouk and Schulze boiled their solutions; Spek evaporated his solutions on slides to dryness. Kunike (28, p. 235) advised using a 5–20 per cent alkali solution, treating the material in stoppered flasks for several days at 60° C. Although all of these workers were able to obtain more or less chitosan, they did not duplicate at atmospheric pressure Van Wisselingh's excellent conditions for its formation.

In 1924 Van Wisselingh (57, p. 178) justly criticized the simplified methods of others and defended his own, which he had not been able to improve in 26 years; and the latest paper (1928) on the detection of chitin, by Kühnelt (25), vigorously supports the original Van Wisselingh method. Kühnelt (p. 380) says that the heating of small objects in open vessels results in injury to them by the *unavoidable* boiling of the solution. Apparently it has never occurred to workers on chitin that boiling can be avoided at 160° C. under normal atmospheric pressure simply by increasing the concentration of potassium hydroxide¹³ to that of a solution saturated at room temperature. And when such a solution is heated in tubes closed by Bunsen valves, the loss of water by evaporation is so slight, even during an hour at 160° C., that the tubes can be cooled again to room temperature without causing the solute to crystallize. In this way the present writer has duplicated at atmospheric pressure the conditions of Van Wisselingh's sealed tube method and has treated successfully the most delicate as well as the most resistant insect structures; e. g., peritrophic membranes and beetle elytra.

Kühnelt (25, p. 380) asserts reasonably enough, but without proof, that the hydrolysis of chitin to chitosan is slower at atmospheric pressure than in sealed tubes. The present writer compared the rate of chitosan formation in Bunsen tubes and sealed tubes, using a saturated solution in the former and 50 per cent alkali¹⁴, as recommended by Kühnelt, in the latter. A single piece of pure crab chitin was cut into six parts of equal size. Three pieces were placed in Bunsen tubes and three in

¹³Potassium hydroxide cannot be replaced by sodium hydroxide in the writer's method.

¹⁴The undefined expression, "50 per cent potassium hydroxide solution," may have such a variety of meanings that the writer does not know whether the solution he prepared, containing 1 part by weight of 85–88 per cent potassium hydroxide and 1 part by weight of water, is the same as that recommended by Kühnelt.

sealed tubes. All six tubes were heated in the same bath. When the temperature of the bath reached 160° C. after 20 minutes preheating, a Bunsen tube and a sealed tube were removed and cooled rapidly. At the end of 10 minutes at 160° C. another pair were removed, and the last pair were taken out at the end of 15 minutes at 160° C. All of the pieces treated in Bunsen tubes dissolved quickly and completely in 3 per cent acetic acid, whereas none of those treated in sealed tubes did so, a small portion of each remaining undissolved in the acid the next morning. The Bunsen tube method is, therefore, faster than the sealed tube method when 50 per cent alkali is used in the latter.

The writer can think of only one possible advantage that sealed tubes may have over Bunsen tubes. Pressure within the former might prevent the expansion of gases within the material and its consequent swelling or disruption. Although this may be the case in fungi, with which Van Wisselingh worked, where chitin occurs in the cell walls, it does not seem to be a disturbing factor in chitinous insect material when parts of cuticula or intima are tested or whole insects are opened and the tissues removed as far as possible before treatment.

Kunike (28, p. 235) condemns the use of concentrated alkali, which the writer has just recommended, because it does not remove substances associated with chitin. Unfortunately, no proof for this statement is given. The present writer does not know to what extent admixtures^{1b}, as the associated substances may be called, are dissolved by the Bunsen tube treatment; but he does know that chitinous objects so treated give the same specific tests as the most carefully prepared, reprecipitated, and washed chitosan. In other words, if admixtures are present after the Bunsen tube treatment, they do not interfere with subsequent tests for chitin. In every case yet tested by the writer, the Bunsen tube treatment is successful wherever other methods succeed.

The transfer of delicate objects from concentrated alkali to water by way of alcohol was proposed by Van Wisselingh (55).

^{1b}Schulze (40, p. 135) called the associated substances "Inkrusten," a term which has been used by all German writers since 1921. But the English equivalent of this term, "incrustations," is unsatisfactory, because it implies that these substances are laid down *upon* chitin after the latter has been formed by epidermal cells. It is probable, but not yet proved, that they are laid down *with* chitin and are most intimately associated with it.

In this way violent dilution stresses on the material are prevented, and the objects are hardened. The number of grades of alcohol to be used depends on the nature of the material.

The conversion of chitinous material into chitosan having been discussed, the microchemical reactions of chitosan will now be considered.

To Van Wisselingh (55) is also due the microchemical application of the violet color reaction with iodine-dilute acid for chitosan, used without change by the present writer. This reaction is remarkably uniform on chitosan of widely different origins. Iodine color reactions are not specific for particular polysaccharides; but the violet color on chitosan is practically specific, because only one other organic compound, cellulose, is known to withstand alkali treatment used for the preparation of chitosan, and its color reactions, already described, are quite different.

Schulze (41, p. 390) and Brunswik (8, p. 113) believe that chitin also may be colored violet by iodine-dilute acid. There is no reason why this should not be the case, but Kühnelt (25), who made a special effort to settle this point, found that pure chitin was invariably colored brown by iodine-dilute acid. The present writer agrees with Kuhnelt and adds the observation chitin precipitated from its solution in concentrated hydrochloric acid, thoroughly washed in water, alcohol, and ether, and dried in a vacuum desiccator is also colored brown by iodine-dilute acid. Quantitative work on this question is, however, desirable.

The possibility of the presence of some polysaccharide other than chitosan or cellulose in material to be tested for chitin makes it desirable to check the Van Wisselingh reaction by a more specific test. We are indebted to Brunswik (8) for the description of a microchemical method for obtaining characteristic crystals of chitosan sulphate from chitosan following the Van Wisselingh test. Brunswik recommended that the violet color be obtained by acidifying the test object with 10 per cent sulphuric acid, instead of 1 per cent acid, and that the object then be dissolved in this drop by heating the slide. Crystals of chitosan sulphate were then to be obtained by exceedingly slow cooling of the slide. The writer found it difficult to get crystals large enough for study, and experience and practice seem to be necessary for the successful operation of this method.

The writer's modification of it is so simple and certain that any student without experience could apply it successfully. His use of 75 per cent sulphuric acid has the additional advantage of revealing cellulose if it is present.

The writer noticed that spherites obtained by his dilution method were always circular in outline, whereas Brunswik's spherites obtained by cooling were always tetragonal. The

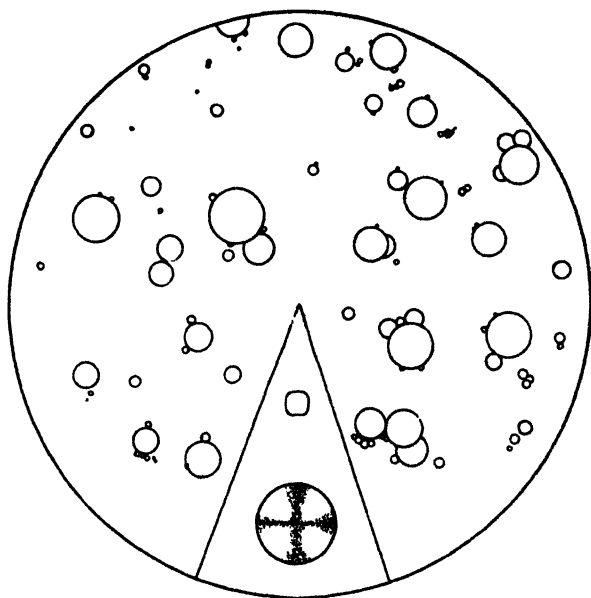


Figure 1. Spherites obtained by slow dilution of a solution of chitosan in 75 per cent sulphuric acid. One of the largest crystals obtained, 19μ in diameter, is shown in the sector to illustrate the appearance of the spherites under polarized light. The smaller crystal in the sector is the tetragonal spherite obtained by slow cooling of a solution of chitosan in dilute sulphuric acid.

two forms are shown in Figure 1. The tetragonal form has hitherto been considered characteristic of all chitosan salts. According to Löwy (31, p. 51) chitosan sulphate has exactly the same tetragonal form as chitosan hydrochloride figured on page 173 by Von Fürth and Russo (14). The present writer, therefore, hesitates to call his spherical crystals chitosan sulphate, although nothing is known which would lead us to believe that some other salt could crystallize out of a solution of pure chitosan in sulphuric acid. It would seem that the difference in appearance is due merely to the difference in con-

dition under which the crystals are formed. At least, it can be said in favor of their identity that both forms show the black (Brewster's) cross (Fig. 1) under polarized light, both seem to have the same index of refraction, 1.52-1.53¹⁶ (convincingly accurate determinations could not be made on either form), and both are stained by the same acid dyes. Whether or not the spherical crystals are chemically the same as the tetragonal form, they are indicative of the presence of chitosan and hence of chitin. Neither chitin nor cellulose dissolved in 75 per cent sulphuric acid yield crystals of any kind by slow dilution of the solution. The same spherical crystals are obtained from crab and from insect chitosan.

The formation of sufficiently large spherical crystals results from the slow dilution of sulphuric acid solutions of chitosan. Slow dilution is accomplished automatically by the absorption of water from the air by the hygroscopic acid. The higher the concentration of chitosan in 75 per cent sulphuric acid, the less is the dilution needed to produce the crystals. In summer, when the relative humidity of the laboratory air is high, crystals were invariably obtained when the drop was exposed to the air of the room, but in winter, when the room is hot and relatively dry, crystals were formed only when the concentration of the solution of chitosan was very high. In order, therefore, to assure the formation of crystals, if chitosan is present, it is always desirable to let the slide stand over water.

The recommendation of 75 per cent sulphuric acid is based on tests of a series of concentrations from 25 per cent to concentrated acid. The latter can be used successfully, but a concentration of about 75 per cent by volume gave the best results. A drop no larger than necessary to cover the object should be used. It does not matter if the drop is not large enough to dissolve the entire object, for the chitosan residue will be washed off the slide with the drop and the crystals alone will remain.

Another excellent color reaction for chitosan devised by Van Wisselingh (56, p. 185) will be mentioned here because, in the writer's tests, it made visible certain structures of cockroach endocuticula. Chitosan forms an insoluble compound with

¹⁶The equipment and advice of Mr. C. M. Smith, of the Food, Drug, and Insecticide Administration of the United States Department of Agriculture, were generously placed at the disposal of the writer for the study of the optical properties of these crystals.

ferrocyanic acid. A drop of 1 per cent potassium ferrocyanide in dilute sulphuric acid is placed on the test object which is then thoroughly washed with water. The chitosan ferrocyanide formed on the surface of the object is invisible and must be developed, as it were. For this purpose a solution of a ferric salt, iron alum, is placed on the object and Prussian blue is formed on its surface in such a way that it appears to be stained with a blue dye. Permanent mounts of the results of this test can be made in balsam. Many other suggestions for micro-chemical chitosan reactions can be found in Van Wisselingh's papers (56, 57).

An entirely different method for preparing and testing chitinous material has been described, discussed, and applied by Schulze (40, 41, 42) from 1921 to the present time. Pigmented cuticula is bleached at room temperature in a solution of chlorine dioxide in acetic acid or, if naturally colorless, is allowed to stand for 24 hours in this reagent. It is then washed and placed for one minute in a solution of zinc chloriodide. While it is being washed in water again, the cuticula turns violet.

It is Schulze's theory that chlorine dioxide has a selective action on the substances of the cuticula. All substances other than chitin are supposed to be removed from the cuticula at room temperature more thoroughly than their removal can be accomplished by alkali at high temperature. The violet zinc chloriodide test is then given by pure, or nearly pure, chitin (not chitosan). In spite of its alleged powerful effect on cuticula, chlorine dioxide, as used by Schulze, is said to have no effect on insect tissues (a truly remarkable reagent!).

If Schulze's theory is correct and the zinc chloriodide test is specific for chitin, the Van Wesselingh and Brunswik tests are superfluous and relatively too troublesome to be used. For several years Schulze and his student Kunike (28) applied the new method enthusiastically, but without a critical examination of its chemical basis. In 1928 Kühnelt (25) published the first critique of Schulze's method. He came to the conclusion that, instead of being better than the Van Wisselingh-Brunswik methods, it is less dependable for the following reasons: Although the violet zinc chloriodide reaction is given faintly by pure chitin, its deep color in material treated by chlorine dioxide is due to adsorbed chlorine which is difficult to remove.

The zinc chloriodide test is not specific for chitin, but is given by other polysaccharides and even by certain inorganic substances. Finally, Schulze's method usually fails to detect chitin in the cuticula of the caterpillars *Bombyx mori* and *Dasychira pudibunda*, whereas, Van Wisselingh's alkali method, with pretreatment of this cuticula in glycerine at high temperature or by bleaching in potassium chlorate-hydrochloric acid, is always successful. The writer finds that the Bunsen tube treatment alone is sufficient preparation for the detection of chitin throughout the cuticula of *Bombyx mori*.

On the other hand Kuhnelt showed that Van Wisselingh's method, with Kuhnelt's pretreatment, makes it possible unfailingly to detect chitin in the exocuticula of certain beetle elytra, e. g., *Lucanus cervus*, which Schulze had asserted (40, p. 135; 41, p. 390) could be prepared successfully only by chlorine dioxide treatment. The writer found that the Bunsen tube treatment alone decolorized the thick, heavily pigmented tips of the elytra of *Lucanus cervus* within 15 minutes at 160° C. and converted chitin completely to chitosan. All chitinous layers of the elytra, including the exocuticula, gave the characteristic violet reaction with iodine-dilute acid.

The writer does not mean to imply by the foregoing that Schulze's method is not good, but that at the present time it cannot be used with confidence because of the lack of knowledge of the effect of chlorine dioxide on insect cuticula. The only evidence offered by Schulze for the ability of chlorine dioxide to remove "grundlich" from cuticula those substances associated with chitin, is the fact that treated cuticula dissolves in concentrated sulphuric acid to a colorless solution, whereas untreated cuticula, whether pigmented or not, gives a brown solution. But it has not been proved that chitin is the only substance in the cuticula which does not give a brown solution. Moreover, it is not known what effect, if any, chlorine dioxide has on chitin itself. Since sodium hypochlorite can oxidize chitin, it is reasonable to suppose that other chlorine-oxygen compounds might have some effect on it. Quantitative work on these questions is needed.

Other color tests for chitin, the α and β naphthol tests of Schulze and Kunike (44) and the thymol test of Kraft (23) need not be discussed here because they are general carbohydrate reactions.

THE QUALITATIVE DISTRIBUTION OF CHITIN IN INSECTS.

Two general questions will first be considered: Whether chitin may be absent, and whether it may occur in a pure state in certain areas of insect cuticula.

According to statements¹⁷ in recent text-books, chitin occurs only in sclerites; membranes are non-chitinized. Such views, however, are not based on chemical tests, but on the preconceived idea that the hardening of sclerites, following ecdysis, is due to the deposition or formation of chitin within them, which leads to the assumption that flexible membranes do not contain chitin.

What are the facts? The discoverer of chitin (36, p. 37) showed that an *entire* insect exoskeleton could be prepared by maceration in alkali and recommended the method to morphologists. Countless exoskeletons have been prepared by alkali treatment since the time of Odier, and so far as the writer knows, the solution of cuticular membranes has never been recorded. The membranes, therefore, contain chitin, cellulose, or some substance, still unknown, which is insoluble in alkali. The presumption in favor of chitin was strong before the advent of specific chitin tests, but it was not until the beginning of the present century that its presence was demonstrated beyond reasonable doubt by chitosan reactions in the cuticular membranes of representatives of different orders—in *Cynips* and *Musca* by Van Wisselingh (55, p. 380) and in *Periplaneta*, *Dytiscus*, and *Melolontha* by Wester (53, p. 543). The present writer believes that further confirmation of the presence of chitin in cuticular membranes is unnecessary except in one special case.

In the membranous cuticula of the enlarged abdomen of the termite queen¹⁸, if anywhere in the exoskeleton of insects,

¹⁷Imms (17, p. 6): "When newly formed it [the cuticula] is flexible and elastic and it remains in this condition as the intersegmental membranes, the articular membranes of the appendages, and in other situations. For the most part, however, the cuticle forms a hard inelastic exoskeleton which is due to its becoming permeated with a substance termed chitin. The nature of the change is not known, nevertheless both chitinized and non-chitinized cuticle are of general occurrence." Comstock (9, p. 30) makes practically the same statement, but on page 34 contradicts himself: "The conjunctivæ are less densely chitinized than other portions of the cuticula."

¹⁸The writer is indebted to Dr. T. E. Snyder, of the Bureau of Entomology, for providing a specimen of a mature termite queen.

one might expect chitin to be replaced by substances more susceptible to chemical and physical change, because this cuticula cannot stretch to its final enormous dimensions. It must grow continuously, if the insect does not molt, and there is no evidence, direct or indirect, for ecdysis in termite queens. Yet the writer finds that the entire cuticula of the abdomen is chitinous.

Since chitin seems always to be present in insect cuticula, one wonders whether it ever occurs without admixtures. Such a case is not known, for it is usually necessary to treat cuticula in some way for the removal of admixtures before it can be tested successfully for chitin. In the few cases where naturally colorless cuticula gives the zinc chloriodide test for chitin without previous treatment, Schulze (41, p. 390) maintains that admixtures are present nevertheless¹⁹. The present writer finds that all cleaned and dried chitinous parts of the American cockroach lose weight after treatment in alkali; i. e., admixtures are dissolved. Numerous statements²⁰ in entomological literature which imply that certain cuticula consists of pure chitin are probably due not so much to the belief of the writers in the occurrence of pure chitin as to a carelessness of expression.

We have come to the conclusion that chitin, always accompanied by other substances, occurs throughout the exoskeleton. But does it occur in all layers²¹ of the cuticula?

According to Kühnelt (26) the epicuticula does not contain chitin. He finds fatty acids and cholesterol in it. Its properties are similar in many respects to those of the cuticle of leaves.

¹⁹Jacobs (20, p. 9) asserted that the intersegmental membranes of the honeybee consist of pure chitin because they give the zinc chloriodide test without previous treatment for the removal of admixtures. But the present writer found admixtures in this cuticula by treating it with concentrated nitric acid. It turns yellow, whereas pure chitin remains colorless.

²⁰For example, Imms (17, p. 110) writes, "The innermost lining of a trachea is a layer of chitin. . . ." Comstock (9, p. 30) says, "In thin sheets it [chitin] is yellowish in color; thicker layers of it are black," implying that pigmented exocuticula is chitin. Lazarenko (29), throughout a long paper on the formation of cuticula by regenerating epithelium, calls the cuticula chitin. Entomologists who wish to refer to the material of the cuticula or intima, whatever may be its composition, should have a suitable name for it; e. g., hoplin (*ὅπλον*, armor). Chitin would bear the same relation to hoplin that cellulose does to wood, or collagen to cartilage, the former being in each case a well known component of the latter.

²¹Following the suggestion of Mr. R. E. Snodgrass, of the Bureau of Entomology, the writer calls the extremely thin outermost layer (*Grenzlamelle*) the epicuticula, the brittle, pigmented outer layer (epidermis, *Pigmentschichte*) the exocuticula, and the flexible, colorless inner layer (dermis, *Hauptlage*) the endocuticula.

No one seems to doubt that chitin is present in the exocuticle of insects, but we find in recent text-books [Comstock (9, p. 172), Mac Gillivray (32, p. 13), Snodgrass (45, p. 6)] that the endocuticle does not contain chitin but is much like cellulose. The source of this error seems to lie in the work of Ambronn (1). In 1890 Ambronn, a botanist, found that the endocuticle of grasshoppers and bees was colored violet by zinc chloriodide, a reagent which had long been used to demonstrate the presence of cellulose in plant tissues, with which it gives a somewhat similar color reaction. Ambronn, therefore, thought he had discovered cellulose in insects. In 1894 Vosseler (49) asserted before the Württemberg Natural History Society that the endocuticle of insects is like cellulose in every respect. The abstract of this paper in the proceedings of the Society does not indicate that he referred to the work of Ambronn or that he himself had made any experiments to support his statement. Packard (37, p. 30), in his text-book of 1898, quoted Vosseler: "Besides the external chitinous layer, there is an inner layer which agrees entirely with cellulose." In 1906 Tower (48, p. 184) repeated the same statement as if he had confirmed its truth: "This [inner] layer is, as is well known (Vosseler, Tower), a carbohydrate allied to tunicin." But if Tower did test the endocuticle, he did not describe his methods in his earlier papers. The later text-book writers seem to have drawn their misinformation from Tower, but the truth of the matter was known long before their books were written. Soon after the publication of Ambronn's work, Krawkow (24) and Zander (60) showed that the endocuticle of arthropods contains chitin, not cellulose. Wester in 1910 (53, p. 550) proved conclusively that cellulose does not occur in the cuticle of several species of insects. Kunike (28), using methods which would have detected cellulose if it had been present, did not find it in a large series of insects. As a matter of fact, it is generally easier to detect chitin in the endocuticle of insects than in the exocuticle.

We turn now to special questions of a controversial nature. According to Imms (17, p. 101) there are two types of peritrophic membranes. The first is supposed to be continuously secreted at the junction of the fore-intestine and mid-intestine and "on account of its resistance to the action of alkalies, it is inferred to be of a chitinous nature." A peritrophic membrane

of this type from *Periplaneta* was shown to be chitinous by Wester (53, p. 543). His observation was confirmed by the present writer. Imms's second type, represented in the honeybee, is supposed to be formed by the delamination of the inner or free margins of the cells lining the mid-intestine. He says, "It is evident that in these instances it is a non-chitinized structure quite different from the usual type of peritrophic membrane described above." But the present writer finds chitin in the peritrophic membrane of the honeybee. It reacts in quite the same way as the membrane of the American cockroach. Snodgrass believes that all peritrophic membranes are of the second type. He writes (45, p. 162), "The old idea that the peritrophic membrane of insects is a backward prolongation of the chitinous intima of the proventriculus has been discredited in all recent investigations on its origin." If he is correct, we must admit that the ability of the cells of the mid-intestine to form chitin is quite general among insects.

All text-book writers seem to agree that the intima of tracheæ is chitinous. Since it is easy to demonstrate the presence of chitin in the larger tracheæ of the American cockroach, the present writer anticipated no difficulty in detecting it in the tracheæ of other insects. The air sacs of the house fly and tracheæ attached to them were tested because Van Wisselingh (55, p. 682) was unable to find chitin in them. Although repeated tests were made on this material and on the air sacs of the honeybee with the attached tracheæ, the present writer could not detect chitin in them. It is the more surprising, because taenidia occur in the intima of this material, except in the air sacs of the honeybee. The problem of the distribution of chitin in the tracheæ of insects has as yet hardly been touched.

Wester (53, p. 548) seems to be the only one who has tested the eggshells of insects for chitin by the use of chitosan reactions. He found no chitin in the eggshells of several species of Lepidoptera. The present writer tested the eggshells of a grasshopper, *Melanoplus differentialis*, and of the American cockroach. The chorion does not contain chitin, but when the egg has developed to a point where the blastoderm cells have laid down a membrane upon the chorion, that membrane contains chitin.

Cockroach oothecæ were thought by Duchamp (11), who first studied them chemically, to be chitinous, and were called chitinous by several later writers. Ito (19, p. 364) in 1924 compared the solubility of oothecæ and chitin in various reagents and decided that oothecæ were not chitinous. The present writer agrees with him, but could not confirm his observation that oothecæ are completely soluble in alkali. After treatment in Bunsen tubes for an hour at 160° C., a colorless, ragged, alveolar membrane remains. It gives none of the chitosan reactions. One specimen so treated was placed in a potassium chlorate-hydrochloric acid mixture for several days. It was treated again in the Bunsen tube, but gave no chitosan reactions. It did not dissolve on standing in 75 per cent sulphuric acid.

The scabs which form over wounds in the cuticula of the American cockroach do not contain chitin.

THE QUANTITATIVE ESTIMATION OF CHITIN IN INSECTS.

The obvious way to determine the percentage of chitin in cuticula is to clean, dry, and weigh the cuticula, dissolve out admixtures by alkali treatment, and wash, dry, and weigh again. But Wester (52, p. 293) pointed out that accurate determinations cannot be made in this way because we have no means of knowing when, or whether, all admixtures are removed or how much chitosan is formed in the process. Bernhart (4) attempted to estimate the percentage of chitin in ergot by dissolving the weighed, alkali-treated material in concentrated hydrochloric acid and weighing chitin precipitated by dilution in the cold. But some loss may take place through hydrolysis or incomplete precipitation of chitin. It seems feasible also to convert chitin completely to chitosan, weigh, and multiply by a factor to get the weight of chitin. But the value of the factor is uncertain and admixtures might not be completely removed.

Since errors can hardly be avoided, the writer has tried to use the first and simplest method in such a way as to remove admixtures with the formation of as little chitosan as possible. Abdominal cuticula of the American cockroach was freed from tissue by scraping it under water with a rather blunt scalpel. The work was carried on very carefully under a binocular microscope until not a visible trace of tissue remained. Since

this operation is tedious and time-consuming, each determination was made on material from a single insect. Not more than 9 mg. (whole sclerites) nor less than 0.4 mg. (intersegmental membranes) of cleaned material in pieces of a size that could be seen and handled was dried in a vacuum desiccator and weighed on a microbalance to within 0.01 mg. The pieces were allowed to stand in a potassium hydroxide solution (concentration, 15-20 grams per 100 cc. water) in an oven at about 60° C., for 2 weeks. Under these conditions pigmented parts are decolorized in 2 or 3 days. At the end of the period of treatment, the pieces were transferred to water. All transfers were made with forceps, under a microscope to be sure that no pieces were overlooked. They were then passed through 4 dishes of water and were allowed to stand over night in water; then through 2 dishes of absolute alcohol to ether, which on evaporation left them snowy white. After standing in a vacuum desiccator for several days, the pieces were weighed again.

Some chitosan was formed in this material, because spherites were obtained from its solution in sulphuric acid, but the conversion was not complete, because it did not dissolve appreciably in dilute acetic acid. Although admixtures might not have been completely removed, the following observations indicate a fairly thorough purification: Two sets of pieces which weighed 1.57 and 2.84 mg. respectively after two weeks' treatment weighed 1.55 and 2.78 mg. after two weeks' further treatment. The original weights were 4.21 and 8.52 mg. After the foregoing treatment Millon's test for proteins in the cuticula was negative, and no visible ash was left after ignition. For the benefit of those who have confidence in the sulphuric-acid test for admixtures, it might be added that treated material gave a colorless solution in concentrated sulphuric acid.

By the foregoing method the abdominal sclerites of the American cockroach were found to contain about 35 per cent chitin. The writer knows of only two other determinations²²

²²There are a number of chitin determinations on record, based on the live weight or dry weight of whole insects. Bounoure (5) analyzed 38 species of Coleoptera and found that the percentage of chitin on a live weight basis ranged between 5 and 15 per cent, being higher for phytophagous beetles. On a dry weight basis, Wolff, Funke, and Dittmann (58, p. 251) found 16 per cent in May beetles, Zaitschek (59, p. 615) 8 per cent in May flies, and Wester (52, p. 293) 10 per cent in cantharids.

of the percentage of chitin in insect cuticula. Odier (36, p. 33) found 29 per cent in elytra of May beetles and Komori (22) 37 per cent in the pupal skins of cicadas. The figures indicate from 30–40 per cent chitin and 60–70 per cent admixtures in insect cuticula. In view of the predominance of admixtures, it might be expected that they would contribute to, or determine, some of the important properties of cuticula.

THE IRRELATION OF "CHITINIZATION" TO HARDNESS AND
PIGMENTATION OF THE CUTICULA OF THE
AMERICAN COCKROACH.

An impression has persisted in the minds of entomologists up to the present time²³ that the inflexibility and hardness of the sclerites of insects are caused by the presence of chitin in them. And since the hard exocuticula is usually pigmented, entomologists have been accustomed to associate pigmentation with chitinization. Taxonomists and morphologists have accepted this alleged relationship without question and have been accustomed to describe parts of the exoskeleton as heavily chitinized, weakly chitinized, or non-chitinized according to the relative flexibility or pigmentation (particularly the latter) of the parts.

Several facts are already known which cast doubt on this supposed relationship and none support it. First, alkali treatment makes hard, brittle cuticula flexible. The obvious explanation is that alkali removes admixtures which cause the hardness of exocuticula. Indeed, because of the softening effect of alkali treatment, one entomologist confessed to the writer that he had thought that the chitin must be removed by the alkali. Of course, it might be argued that inter-molecular or intra-molecular changes, and not the removal of a specific hard substance, softens cuticula. Second, non-chitinized areas, with the possible exception of pores, are not known to occur in the exoskeleton of insects. It does not seem reasonable to suppose that the hardness of exocuticula is due to chitin, since it is also present in soft parts, some of which, as the endocuticula, are usually thicker than the exocuticula. Comstock

²³Metcalf and Flint (33, p. 72), in 1928, say: "This change from flexible to stiff cuticula is due to a chemical process and the hard material formed is called chitin."

(9, p. 34) explains away this difficulty by assuming that the flexible parts are less densely chitinized.

Ferris and Chamberlin (12) rightly considered the foregoing reasons sufficient for protesting against further use of the terms "chitinized" and "non-chitinized" to indicate relative hardness and pigmentation of cuticula. To replace them they proposed the logical adjectives "sclerotic" and "sclerotized"²⁴. They perceived the likelihood that admixtures are the cause of hardness. Schulze (40, p. 135) had long ago taken it for granted, for he speaks of "hartende Inkrusten."

The following facts, already known, are in favor of the view that certain admixtures are the cause of inflexibility and hardness. It is easy to find chitin in flexible cuticula but it is often difficult to detect it in hard exocuticula, presumably because of the predominance of admixtures in the latter. Certain hard, pigmented structures, such as cockroach oothecae, which would certainly be called heavily chitinized by a morphologist, do not contain chitin.

However convincing the foregoing qualitative evidence may seem, it might still be argued that the hard substance of the ootheca may be quite different from that of the exocuticula of the cockroach, and that the exocuticula may be more "densely chitinized" than the endocuticula and the intersegmental membranes. The writer, therefore, decided to attempt the determination of the percentage of chitin in exocuticula and endocuticula of the American cockroach and in the intersegmental membranes of this insect.

With a sharp scalpel the endocuticula was stripped as completely as possible²⁵ from the exocuticula and the percentage of chitin was estimated in the two layers as already described. Three sets of determinations were made, each on material from a different insect. The exocuticula contained

²⁴It is interesting to note that American entomologists are not alone in their confusion about chitinization. In commenting on an illuminating talk by Schulze (43), Hase said, "Wir haben gehört, dass am Chitin eigentlich nur das wenigste 'Chitin' ist. Wie soll man unter diesen Umständen in Zukunft Angaben wie 'starke Chitinisierung' und ähnlich ausdrücken, um wissenschaftlich einwandfrei zu sprechen?" Ferris and Chamberlin have given an answer to the question.

²⁵If cuticula is allowed to stand for several days in a mixture of glycerine and hydrochloric acid, as proposed by Kunike (28, p. 245), and then soaked in water, an easy and perfect separation of the two layers can be obtained. The present writer doubts, however, that admixtures are not "zerstört," as claimed by Kunike, because untreated endocuticula contained not more than 65 per cent of chitin, whereas, after treatment in Kunike's mixture, it contained as much as 91 per cent.

23 per cent, 22 per cent, and 22 per cent, the endocuticula 65 per cent, 57 per cent, and 57 per cent respectively, a significant difference. The inflexible pigmented layer proved to be "weakly chitinized" and the flexible colorless layer "heavily chitinized²⁶." It seems to the writer that this quantitative evidence in conjunction with the more general qualitative evidence already mentioned is incontrovertible proof that the hardness and inflexibility of the exocuticula are due not to chitin but to certain admixtures.²⁷

The so-called "non-chitinized" intersegmental membranes contain at least 27 per cent of chitin. It is so difficult to clean and handle such delicate material that this figure should probably be higher. It is not to be expected that, because the membranes are flexible, the percentage of chitin in them should be as high as it is in endocuticula. Exocuticula is generally present in intersegmental membranes, but, either because of its thinness or because of its discontinuous structure, called "Kegelbildung" by Kühnelt (27), it does not interfere with flexibility.

There is no relation between pigmentation and chitinization of structures in the American cockroach. For example, heavily pigmented oothecæ contain no chitin; exposed regions of abdominal sclerites, which superficially look the same, contain 33 per cent; the nearly colorless regions, covered by the preceding sclerites, contain 37 per cent; the colorless cast skins of newly hatched cockroaches contain 35 per cent.

It has been shown that the inflexibility of the cuticula of the American cockroach is not due to chitin nor is pigmentation associated with chitin. But it is still necessary to test the assumption of Imms (17, p. 6) that shortly after ecdysis and during the hardening process the cuticula becomes "permeated" with chitin. The present writer was fortunate to have observed

²⁶In agreement with this fact Kühnelt (27, p. 247) says of the endocuticula. "In chemischer Hinsicht zeichnet sich die Hauptlage durch das starke Hervortreten des Chitins aus, so das andere Stoffe nur eine ganz untergeordnete Rolle spielen." His statement, however, is apparently based on qualitative tests.

²⁷Nothing specific is yet known about the chemical composition of admixtures, but proteins and carbohydrates can always be detected by general qualitative tests. It would seem logical to look for a scleroprotein as the specific hardening agent. Nothing is known either about the nature of the hardening process. It might be studied to advantage in cockroach oothecæ, where chitin does not occur, because the hardening material secreted by gland cells might be qualitatively the same as that secreted by epidermal cells.

a large cockroach nymph in the act of molting. Immediately after the insect was free, it was chloroformed and the flexible colorless abdominal sclerites were carefully prepared for analysis. This material contained an amount of chitin, 35 per cent, which appears to be normal for hardened cuticula. Therefore, it can neither be said that chitin permeates the admixtures at the time of hardening nor that admixtures permeate chitin, a view taken by Ferris and Chamberlin (12, p. 214). It seems more probable that chitin and admixtures are formed concurrently and are laid down in intimate association in about the same proportions in which they are subsequently found in hardened cuticula. The hardening process must consist in some change in admixtures which are present in the cuticula when the process begins.

SUMMARY.

The following modification of the Van Wisselingh-Brunswik tests for chitin is recommended: Material suspected of being chitinous is placed in potassium-hydroxide solution saturated at room temperature and kept at 160° C. for 15 minutes in a tube closed by a Bunsen valve. Following the iodine-dilute-acid test, the material is dissolved on the slide at room temperature in a drop of 75 per cent (by volume) sulphuric acid. Spherical crystals, precipitated by slow dilution of the drop in moist air, cling to the slide, where they may be washed, stained with an acid dye, and mounted in balsam.

By this method chitin was found throughout the exoskeleton of several species of insects, in the peritrophic membrane of the American cockroach and honeybee, and in the blastoderm membrane of cockroach and grasshopper eggs. Chitin could not be detected in the chorion of these eggs, in the air sacs and attached tracheæ of the house fly and honeybee, in the ootheca of the American cockroach, or in wound scabs of this insect.

The prevalent idea that chitin causes the hardness and inflexibility of insect exocuticula is no longer tenable. It was shown that the so-called "heavily chitinized," hard, pigmented exocuticula of the American cockroach contains about 22 per cent chitin, whereas the "non-chitinized," flexible, colorless endocuticula contains about 60 per cent. No relation was found between pigmentation and chitinization in the cuticula of the American cockroach. Adjacent pigmented and colorless areas

of abdominal cuticula contain about the same percentage of chitin, 35 per cent. The hardening of the exocuticula is caused by a chemical or physical change in certain substances intimately associated with chitin, which are present with it in the cuticula when the hardening process begins.

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BOOK REVIEW.

THE PROBLEMS OF APPLIED ENTOMOLOGY. By **ROBERT A. WARDLE**, M. Sc. McGraw-Hill Book Co. New York. pp. I-XII-587.

This very comprehensive survey of the present important problems in entomology discusses in the first part the general problems under such headings as Host Resistance, Climatic Resistance, Tropic Behavior, Disease, Parasites and Predators, Theory of Insecticides, Stomach Poisons, Contact Insecticides, Fumigants and Combination Insecticides and Cultural Influence and, in the second part, the problems of the larger geographical areas with the peculiar conditions pertaining to them. The third part includes a very carefully classified bibliography and index.

H. O.

COLEOPTERA TAKEN FROM BAIT-TRAPS.¹

S. W. FROST AND HENRY DIETRICH.

The Coleoptera in question were taken from more than 1000 traps operated in a peach orchard near Arendtsville, Adams Co., Pennsylvania during the seasons 1926, 1927 and 1928. The traps consisted of fermenting sugar or molasses solutions placed in number ten tin pails, hung six or seven feet high on the trees. They were under close observation from March 15 to November 1, and were replenished every three or four weeks in order to keep them fresh and active. The beetles were secured by straining them from the pails each week and returning the baits to the pails for further catches. An 18 mesh sieve was found satisfactory for straining out the larger insects but one of finer mesh is recommended for micro-coleoptera and smaller insects. The Coleoptera were taken incidentally as a part of a larger project on the value and use of baits for trapping oriental fruit moths. The determinations of the species were made by Mr. Henry Dietrich with the assistance, in a few cases, of Mr. F. C. Fletcher.

Space does not permit a detailed discussion of the numerous baits used in trapping the beetles, but a few general remarks may not be amiss. Some idea of these baits can be secured by reference to three papers by the senior author². For general purposes, molasses 1 part and water twenty parts was found most satisfactory. There are three distinct periods during the operation of these baits; (1) a short period of alcoholic fermentation lasting one or two days during warm weather; (2) a period of acetic fermentation lasting for three or four weeks; and (3) a period of putrefaction during which the bait lost its attractiveness for most insects. During the first and early part of the second periods, Nitidulidæ and some Scarabæidæ, which naturally visit flowers, came freely to the baits.

¹Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 468.

²Except a few records from Aspers or Midvale, Pa., which have been designated.

³Frost, S. W., JI. Econ. Ent. 19: 440-450, 1926; 20: 167-174, 1927; 21: 339-348, 1928.

During the third period, Silphidæ and certain Scarabæidæ were attracted. As a rule baits were not continued after putrefication developed, and as a result, few of the filth-loving beetles were taken.

Liquid baits offer a profitable method of collecting beetles of certain families. Sugaring for moths is an old practice and the use of vinegar or brown sugar to trap beetles as Nitidulidæ

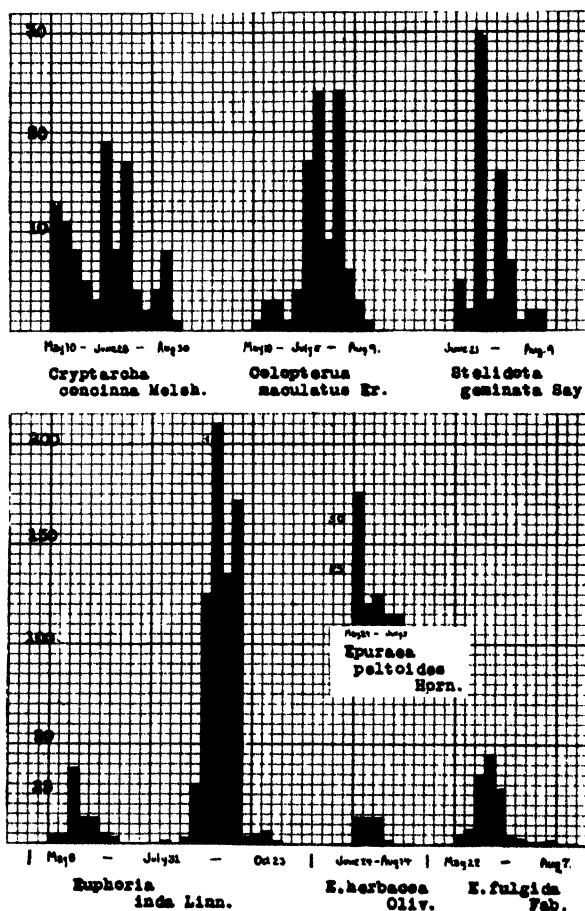


FIG. 1. Relative catches of seven species of beetles taken in bait pails. *Euphoria inda* apparently has two broods.

Space has permitted the mention of only a few of the more interesting species taken in baits. Much might be learned from a study of the occurrence of some of the more common species. The accompanying figure shows in a graphic way the complete records of seven species taken during one summer. Most of them show but one brood occurring over a definite period of time. *Euphoria inda* apparently has two broods or at least is much more abundant during August and September.

is well known, but the use of liquid bait as traps is somewhat new. Champlain and Kirk (1926)⁴ have summarized catches from such baits. The expenditure of labor, time and materials for this method of collecting is insignificant, and there are wonderful possibilities of adapting it for general collecting, especially if such traps are operated in wooded places, swamps etc.

Representatives of 40 of the 111 families of Coleoptera have been taken in baits and practically every major family is represented. A total of 188 genera and 258 species, many of which are rare, have been collected in this way. The Carabidæ, Staphylinidæ, Elateridæ, Nitidulidæ, Cerambycidæ, Chrysomelidæ, Curculionidæ, and Scolytidæ were most conspicuous in number of genera and species represented while the Staphylinidæ, Nitidulidæ and Cerambycidæ were most conspicuous in the number of individuals taken. The abundance of some species indicates that they are attracted by the baits, while the great variety of genera and small number of individuals among families such as the Chrysomelidæ would indicate that these species fell into the trap by accident. It would be impossible to list all of the species taken in the baits but some of the rarer species are worth mentioning. The following list plainly shows where baits are of value in collecting Coleoptera:

COLEOPTERA TAKEN IN BAIT TRAPS, SUMMERS 1926, 1927 AND 1928.

FAMILY	NO. OF GENERA	NO. OF SPECIES	FAMILY	NO. OF GENERA	NO. OF SPECIES
Carabidæ	23	35	Monotomidæ	1	1
Hydrophilidæ	2	2	Cucujidæ	2	4
Silphidæ	3	3	Erotylidæ	2	2
Staphylinidæ	15	18	Cryptophagidæ	1	1
Histeridæ	3	4	Phalacridæ	1	1
Lampyridæ	1	1	Coccinellidæ	3	4
Cantharidæ	3	5	Alleculidæ	1	1
Melyridæ	1	1	Tenebrionidæ	2	2
Cleridæ	4	5	Lagriidæ	1	2
Corynetidæ	3	3	Melandryidæ	2	2
Cupesidæ	1	1	Anobiidæ	1	2
Mordellidæ	2	3	Bostrichidæ	3	3
Pyrochroidæ	1	1	Cisidæ	1	1
Anthicidæ	3	7	Scarabaeidæ	8	19
Elateridæ	11	18	Cerambycidæ	26	32
Melasiidæ	3	3	Chrysomelidæ	17	19
Buprestidæ	4	4	Platystomidæ	1	1
Helodidæ	1	2	Curculionidæ	11	11
Dermestidæ	2	3	Scolytidæ	8	11
Byrrhidæ	1	1			
Nitidulidæ	9	19		188	258

⁴Ent. News 27: 288-291, 1926.

SEASONAL COLLECTIONS.

The Staphylinids were the first to make their appearance in the bait pails. As early as March 16th, several species of the genus *Atheta*, also *Philonthus microphthalmus* Horn, were captured in the baits. A few days later the common scarabaeid, *Aphodius granarius* Linn., was flying and numerous specimens were taken in the pails. On April 20th the Scolytids, *Monarthrum fasciatum* Say., and *Anisandrus pyri* Peck., made their appearance. Soon after this a host of carabids were attracted. From May until August Nitidulidæ were much in evidence. During May, June and July large numbers of *Cantharus*, especially the two species *C. bilineatus* Say., and *C. reclus* Melsh., were very prominent. During the summer Scarabaeidæ were taken in more or less numbers, the common flower visiting species, *Euphoria inda* sometimes covering the entire surface of the liquid in the pails. The Cerambycidæ were likewise often taken in large numbers, *Hypermallus villosus* Fab., and *Elaphidion mucronatum* Say., being most conspicuous. The beetles of the other families were taken in insignificant numbers many perhaps as accidental catches.

Carabidæ.

A surprising number of species of Carabids were taken in bait-pails. The majority of these are rather strong fliers, which probably accounts for their presence in these traps hung on the average of six to seven feet from the ground. Mr. Dietrich's favorite method of collecting carabids is to sink the baits even with the surface of the ground.

The family was well represented by the larger species of the genera *Calosoma*, *Galerita*, *Elaphrus*, *Calathus*, *Platynus*, *Lebia*, *Pinacodera*, *Harpalus*, *Triplectrus*, *Tachistodes* and *Amara*. Many of the smaller species were taken principally during the early part of the summer as follows: *Stenocellus tantillus* Dej., from June 7 to July 12; *S. rupestris* Say, from April 6 to May 14; *Stenolophus conjunctus* Say, from May 7 to July 7; *S. ochropezus* Say, *S. fuliginosus* Dej. and *S. plebejus* Dej., on May 7; *Selenophorus gagatinus* Dej., from May 10 to May 24; *S. opalinus* Lec., June 24; *Dyschirius globulosus* Say, from May 24 to September 20; *Clivinia bipustulata* Fab., August 23; *Tachistodes partiaris* Say, May 8; *Agonoderus pallipes* Fab., May 14 to 21; *Lebia tricolor* Say, July 3; *Pinacodera limbata* Dej., July 24; *P. platycollis* Say, July 31.

Hydrophilidæ.

This family was represented by only two species, *Helophorus lineatus* Say, taken May 14, and *Sphæridium scarabaeoides* L., captured June 12. The former, because of its aquatic habits, is probably an unusual catch in the bait traps, the latter, however, is known to live in damp places or in decaying vegetation.

Silphidæ.

Occasional catches, chiefly *Necrophorus orbicollis* Say, and *Silpha americana* Linn., were made during the summer. These, no doubt, were attracted by baits that had become old and putrid.

Staphylinidæ.

Staphylinids are known to feed upon fermented sap on the stumps of trees, and it is a wonder to the writers that a larger number of these species were not captured. No doubt if a sieve of a smaller mesh had been used in separating the beetles from the bait, some of the minute species would have been taken. Many of the species are powerful fliers, bringing them into the proximity of the baits that were hung in the trees. They were the first beetles to be trapped in the spring and were taken at intervals during the summer. Several subfamilies were represented, but only single specimens were taken of most of the species. Fifteen specimens of one rare species, *Ephelinus notatus* Lec., were taken on May 17, one on an earlier date, May 7, two on June 2, and five on June 7.

The subfamily Omaliinæ was represented by three species: *Olophorum oblectum* Er., captured April 26 to May 10; *Arpedium Schwarzi* Fauv., May 3; and *Ephelinus notatus* Lec., as noted above. A single species, *Stenus arculus* Er., of the subfamily Steninae was taken on July 15. The subfamily Paederinae was represented by two species; *Hesperobium cribratum* Lec., captured on May 12; and *Lathrobiella rubida* Csy., taken on June 7.

Five species of the subfamily Staphylininae were taken: *Philonthus umbratilis* Grav., August 30; *P. microphthalmus* Horn, March 17; *Staphylinus mysticus* Er., May 10; and *Quedius* sp.

The subfamily Tachyporinae was well represented by a number of genera and species. *Tachinus pallipes* Grav., was taken June 28; *Tachyporus nitidulus* Fab., July 12; *T. scitulus* Er., May 8, at Midvale; *Conosoma* sp., May 19, at Aspers; *Bolitobius intrusus* Horn, May 19 and June 28, at Aspers; *Mycetoporus consors* Lec., May 10.

The subfamily Aleocharinae was represented by several species of Atheta taken during the early part of the summer, from March 17 to June 28. Some of this subfamily are very small and probably passed through the sieve or decomposed in the bait.

Histeridæ.

Only a few specimens were taken at intervals; *Ihister abbreviatus* Fab., *Ihister harrisi* Kby., *Ihister americanus* Payk., and *Carcinops quatuordecimstriata* Steph. They were probably attracted by the decomposing bait.

Lampyridæ, Cantharidæ and Melyridæ.

Lampyridæ were rare in baits, a single species *Pyractomena borealis* Rand, was taken July 10. *Cantharus rectus* Melsh., and *C. bilineatus* Say, came to baits in very large numbers during May, June and July, while *C. rotundicollis* Say, was found in smaller numbers, and a single specimen of *Polemus laticornis* Say was taken June 10. A species of *Attalus* was also taken in baits.

Cleridæ.

A few Cleridæ were taken, but none in abundance. One specimen, *Ilydnocera pallipennis* Say, generally considered rare, was taken September 20. The common species *I. unifasciata* Say, was taken on July 19 and 26; *Plæopterus thoracicus* Oliv., June 26 and July 3; and *Enoclerus nigripes* Say, July 7.

Corynetidæ.

Two rare species were taken: *Neichnea laticornis* Say, July 15, and *Cregya oculatus* Say, July 19, and the common species *Phyllobaenus dislocatus* Say, July 31.

Cupesidæ.

The rare species *Cupes concolor* Westw., was taken on August 7.

Mordellidæ and Pyrochroidæ.

Species of the genera *Mordella*, *Mordellistena* and *Neopyrochora* were taken in small numbers during July. All were probably accidental catches.

Anthicidæ.

This family was well represented during the early part of the summer. There was evidence that the beetles had been attracted by the odor of the bait. *Notoxus bicolor* Say, was taken from May 24 to July 5; *Notoxus monodon* Fab., from April 26 to July 5; *Mecynotarsus elegans* Lec., on May 10; *Anthicus cervinus* Laf., April 26 to June 7; *A. vicinus* Laf., from April 26 to June 7; *A. haldemani* Lec., on May 10; and *A. formicarius* Laf., on May 7.

Elateridæ.

The Elateridæ were numerous during June and July, the species of the genus *Melonomotus* being most abundant, namely, *M. communis* Gyll., *M. fissilis* Say., and *M. depressus* Melsh. Species of the genera *Aeolus*, *Athous*, *Ludius*, *Hemicrepidius*, *Hypnoidus*, *Crigmus*, *Parallellostethus*, *Glyphonyx*, *Dolopius*, and *Elater* were also taken. Several of the species are common visitors of peach trees and are often seen resting upon the foliage. No doubt many of the captures were accidental. The most unusual catch was a single specimen of *Parallellostethus attenuatus* Say., taken May 30.

Melasidæ.

An occasional specimen was taken during July. Three genera were represented, *Isorhipis*, *Microrhagus* and *Nematodes*, the latter yielding two rare species, namely, *M. imperfectus* Lec., taken July 12, and *N. penetrans* Lec. July 26.

Buprestidæ.

The Buprestidæ were only occasional visitors to the baits, and probably accidental catches. Species of the genera *Agriaxia*, *Chrysobothris*, *Agrius* and *Brachys* were taken. *Chrysobothris femorata* Oliv., a species that bores in apple and peach, was taken quite often.

Helodidæ, Dermestidæ and Byrrhidæ.

Occasional catches of representatives of the genera *Cyphon*, *Attagenus* and *Trogoderma* were made. They were probably attracted by decomposing baits after fermentation was completed. One hundred twenty-seven specimens of *T. ornata* Say, were taken from June 7 until August 9. *Cytilus alternatus* Say was captured May 7 and 21.

Nitidulidæ.

This family was most conspicuous in collections from bait pails. This might be expected as the great majority of the species feed on sap or juices of different kinds, especially when they begin to ferment. Representatives of three subfamilies and a large number of species were taken throughout nearly the whole summer and sufficient material was secured in some cases to plot graphs.

The subfamily *Carpophilinæ* was represented by two genera and eight species. *Colopterus maculatus* Er., was taken continually from May 10 to August 9; *C. truncatus* Rand., from May 10 to August 30. The genus *Carpophilus* yielded six species; *C. hemipterus* L., taken on July 12 and August 9; *C. niger* Say, on June 7; *C. corticinus* Er., May 10 to July 5; *C. brachypterus* Say., almost continually from July 7 to September 30; *C. antiquus* Melsh., on June 2; *C. nitens* Fall., 1 ♂ June 28, 1 ♂ July 2, 1 ♂ July 15, 1 ♂ July 26, 3 ♂ September 3. The latter species has apparently not been taken since it was described from Mobile, Alabama.

A number of individual captures occurred in the subfamily *Nitidulinæ*: *Omosita colon* L., taken July 7 and July 15; *Epuræa peltoides* Horn, May 24 to July 19; *Stelidota geminata* Say, abundant from June 21 to August 9; *Lobiopa undulata* Say, on May 24, July 5 and August 23; and *Cychramus adustus* Er., on June 21.

The subfamily *Cryptarchinæ* was well represented by two genera and five species which came to the bait pails in large numbers throughout the summer. *Cryptarcha ampla* Er., was taken continually from May 10 to July 26; *C. strigata* Fab. From June 2 to August 30; *C. concinna* Melsh., from May 10 to August 30; *Glischrochilus fasciatus* Oliv., from May 8 to August 9; *G. sanguinolentus* Oliv., taken only on May 10; and the rare *G. obtusus* Say, on July 10.

**Monotomidæ, Cucujidæ, Erotylidæ, Cryptophagidæ,
Phalacridæ, Coccinellidæ, Alleculidæ,
Tenebrionidæ, Lagriidæ.**

A number of genera and species of these families were captured, all apparently by accident. The genera *Europs*, *Catogenus*, *Laemophloeus*, *Languria*, *Tritoma*, *Henoticus*, *Acy-lomus*, *Stilbus*, *Hyperaspis*, *Brachyacantha*, *Chilocorus*, *Isomira*, *Haplандrus* and *Meracantha* were represented. Both eastern species of *Statira* were taken: *S. gagatea* Melsh. ♀, July 10; and *S. resplendens* Melsh. ♂, July 24.

Melandryidæ.

This family was poorly represented by two species. *Dircaea quadrimaculata* Say, was taken on July 3 and 17, while *Synchroa punctata* Newm., was taken August 2.

Anobiidæ, Bostrichidæ, Cisiidæ.

An occasional specimen representing these families was captured, but none were of particular interest. The genera *Catorama*, *Endecatomus*, *Bostrichus*, *Xylobiops*, and *Cis* were found.

Scarabaeidæ.

A rather large representation of Scarabs was found in the bait pails. Some of the smaller and stronger flying species as *Aphodius granarius* L., and *A. distinctus* Mull., were taken in considerable numbers during their flight in April and May, while *Ataenius cognatus* Lec., and *Serica vespertina* Gyll., were taken in June and July. Several specimens of *Anomala innuba* Fab., were also taken during July. Six species of *Phyllophaga* were captured at intervals but not in large numbers. *Cotinis nitida* L., was captured in moderate numbers from July 10 to August 28.

The genus *Euphoria*, however, came in great numbers and were apparently attracted to the baits. Sufficient material was taken to plot curves for *E. inda*, L., *herbacea* Oliv., and *fulgida* Fab. *E. sepulchralis* Fab., was taken only in moderate numbers during October⁵.

⁵It is interesting to note that *E. fulgida* Fab., on different occasions was seen drinking the honey-like secretion that fills the cup-like glands at the base of peach leaves. When the sweet substance runs low, they use one of the sharp spines on the outer angle of the front tibia to lacerate the glands and cause the juice to flow.

Cerambycidae.

A remarkable number of species were taken considering that the pails were hung in a peach orchard in an open country and distant from any wooded areas. *Hypermallus villosus* Fab., and *Elaphidion mucronatum* Say., were the most conspicuous species, while *Purpuricenius humeralis* Fab., *P. axillaris* Hald., *Ophistomis luteicornis* Fab., and *Strophiona nitens* Forst., were next in numbers. In 1926 *Eburia quadrigeminata* Say., came quite freely during July and August but the following years it was taken only occasionally.

All the species noted by Champlain and Kirk⁶ were taken by the writers with the exception of two species in the genera *Leptostylus* and *Gaurotes*. In addition the following species were captured: *Pseudibidion unicolor* Rand., July 12; *Brachyleptura rubica* Say., July 24; *Strangalepta lineola* Say., June 18; *Molorchus bimaculatus* Say., May 21; *Phymatodes amoenus* Say., May 24; *P. testaceus* L., June 26; *P. testaceus* var. *variabilis* L., June 6-26; *P. varius* var. *albofasciatus* Bland, June 16; *Cyllene robiniae* Forst., Oct. 2; *Neoclytus scutellaris* Oliv., Aug. 7; *N. mucronatus* Fab., Aug. 7; *N. acuminatus* Fab., July 17; *Cyrtophorus verrucosus* Oliv., July 15; *Tilloclytus geminatus* Hald., July 15; *Stenosphenus notatus* Oliv., June 24; *Tragidion coquus* L., Aug. 21; *Psenocerus supernotatus* Say., July 15; *Leiopus alpha* Say., June 28; *Lepturges signatus* Lec., July 17; *Hyperplatys maculata* Hald., June 15; and *H. aspersa* Say., July 5-26.

Crysomelidae.

A large number of species of this family were captured. Many of them, no doubt, were accidental catches, being represented largely by individual specimens.

Curculionidae.

This family was well represented in numbers of genera and species. The specimens were taken singly and scattered throughout the summer. The following genera were taken: *Apion*, *Phyxelis*, *Sitona*, *Phytonomus*, *Curculio*, *Elleschus*, *Madarellus*, *Apteromechus*, *Cryptorhynchus*, and *Hypera*.

⁶Champlain, A. B. and Kirk, H. B. Ent. News 37: 288-291, 1926.

Platystomidæ.

A single specimen of *Brachylarsus sticticus* Boh., was taken July 31.

Scolytidæ.

The attraction of a comparatively large number of scolytids was surprising. Certain species which are usually difficult to obtain, because of their habits, were caught by the baits. Several of the species normally inhabiting pines, oaks and beeches, were taken in baits hung in peach trees some distance from a small wooded area. Their presence in the traps seemed to indicate that they were attracted to the baits. Two species of *Ips* were captured: *I. avulsus* Eich., June 28; and *I. pini* Say, May 3 and July 19. *Monarthrum fasciatum* Say, was taken frequently from April 20 to September 6 and *M. mali* Fitch, was taken on May 10. *Scolytus rugulosus* Ratz., another common species, was captured from July 5 to August 9, while *S. quadrispinosus* Say, was taken July 10. *Hylastinus obscurus* March was captured during May only; *Xyleborus saxeseni* Ratz., from May 24 to June 15; *Leperisinus aculeatus* Say, April 26 and May 7; *Micracis suturalis* Lec., June 7; and *Anisandrus pyri* Peck, on April 20.

ON THE BIONOMICS OF A PRIMARY PARASITE AND OF TWO HYPERPARASITES OF THE GERANIUM APHID.

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The three parasites discussed in this paper are *Aphelinus jucundus* Gahan, *Aphidencyrus inquisitor* (Howard) and *Asaphes americana* Girault.* They all belong to the superfamily Chalcidoidea but differ so markedly in every phase of their development that no trouble has been experienced in recognizing each species, no matter in what stage it was found. The first two species mentioned have been under observation at the Insectary of Cornell University during the greater part of the time since September, 1925. Since November, 1926 they have been continuously reared in breeding cages. The observations on *Asaphes americana* cover a much shorter period. Owing to an insufficiency of material, and to the pressure of other work, it was not possible to make as detailed observations on this species as on the other two parasites.

METHODS.

The geranium aphid (*Macrosiphum cornelli* Patch) has proved an ideal host for the breeding of parasites. Unlike many other greenhouse aphids, it is present at all times of year and can be easily propagated.

Considerable difficulty was experienced at first in finding a satisfactory rearing cage. Before any breeding of parasites could be attempted it was necessary to devise some method that would make conditions entirely satisfactory to the aphids. Geraniums are very susceptible to mildew if the plants are kept under too moist conditions. On the other hand, if a geranium gets too dry, the aphids soon become restless and crawl from the plant. Rearing the insects on growing plants,

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The plates were drawn by Elizabeth K. Burckmyer. All of the figures were drawn to the same scale and are about forty times natural size.

*All three parasites were determined through the courtesy of A. B. Gahan, of the U. S. Bureau of Entomology.

therefore, did not seem to be feasible. Leaves of the common Lady Washington geranium (*Pelargonium domesticum*) will keep fresh for days in water and on leaves so kept the aphids were found to thrive perfectly. Although the development of the aphid is somewhat hastened by this method (Griswold, 1927:92) it is not probable that the development of the parasites is abnormally affected.



Fig. 1. Cage used for breeding parasites.

The rearing cage which was finally adopted and which has been used in practically all of the work under discussion, is shown in figure 1. Although the glass cylinder comes in close contact with the saucer on which it rests, a strip of cotton batting was kept about the bottom of each cage as an added precaution against the entrance of undesirable animal life. Not only has this cage proved satisfactory to the aphids but it

appears to be equally satisfactory to the parasites which are able to move and to fly about in an almost normal manner. A large supply of aphids, free from parasites, was kept on hand in separate rearing cages.

In working out the life histories, a certain number of parasite-free aphid nymphs, of early instars, were exposed each day to the primary parasite for a period of 24 hours or less. Later these same aphids were exposed to the hyperparasites for another, similar period. By making dissections at stated intervals the stage of development could be ascertained. Knowing the date when the egg of the particular species of parasite must have been laid, it was possible to determine the lengths of the various stages in the life cycle. Of course the rapidity of development depends somewhat upon the temperature, but the data given are those found to prevail under normal greenhouse conditions. In the early part of the present study the periods of exposure were usually 24 hours, but later these periods were reduced to 6 hours, in order to secure more accurate data, especially in regard to the lengths of the egg stages. As soon as the aphids turned black they were removed to small shell vials and carefully labeled.

Dissections of living aphids were made in a drop of normal salt solution (7.5 gr. of sodium chloride to 1000 cc. of water). *Minuten nadeln* stuck in small wooden handles were found to make ideal needles for dissecting the larvæ of the primary parasite after these had been removed from their host aphids. After the aphids had died and turned black it was found necessary to paste them to a watch glass or depressed slide before dissections could be made and the parasites within removed.

Aphelinus jucundus Gahan.

(Plate I)

Aphelinus jucundus belongs to the family Aphelinidæ. The insect was described by Gahan (1924:8) from specimens reared from the potato aphid. At the Insectary greenhouse this *Aphelinus* has been commonly reared from the geranium aphid (*Macrosiphum cornelli* Patch) but it has been bred also from the green peach aphid (*Myzus persicae* Sulzer) and from an aphid on rose (*Macrosiphum pseudodirhodum* Patch).* It was

*Determined through the courtesy of Dr. Edith M. Patch, of the Maine Agricultural Experiment Station.

reared also outdoors from an undetermined aphid on cultivated columbine. This chalcid is an internal primary parasite. Its larvæ feed directly on the body contents of the aphids within which they live.

The egg.—The egg is somewhat bean-shaped. Its cephalic end is slightly roughened and more rounded than is the caudal end. The chorion is transparent so that the developing embryo within can be seen. Measurements of 15 eggs gave an average of about 0.26 mm. in length and about 0.07 mm. in width.

The egg is laid in the body fluid of the aphid. The *Aphelinus* will oviposit in aphids no matter what the stage of development of the latter happens to be, although the younger instars seem to be preferred. As previously stated, early instar nymphs were used in most of the breeding work at the Insectary. It is probable that generally but one egg is laid in a host insect, although in the breeding cages as many as four eggs have been found in a single nearly mature aphid or in one that was fully developed. Hatching occurs in slightly less than three days after the egg has been laid.

The larva.—The first stage larva is pale yellow in color and similar to the egg in form. It is somewhat bean-shaped and is more pointed at the posterior than at the anterior end. By the third day after hatching the larva has straightened out and is somewhat spindle-shaped. By the fourth day, it has filled out considerably and become globular, although it is still slightly pointed at the posterior end. It retains this globular shape through the rest of its larval life. Within ten to twelve days after hatching from the egg, the larva has become full-grown. By this time nothing is left of the aphid but a black, hollow shell. Due to the accumulated fecal matter in the alimentary tract, the body of the parasite is now considerably distended and practically fills that of its host. After the excrement has been voided the *Aphelinus* elongates and goes into the pupal stage.

The pupa.—When first formed the pupa is yellow throughout. The eyes and the three ocelli soon take on an orange tone and gradually a darkening shows on other parts. When the pupa is fully colored, the thorax is very dark, almost black, while the abdomen remains yellow except for five dark transverse bands on the dorsal surface. The head is greenish yellow as are the antennæ, the wing covers, and the first pair of legs. The second and third pairs of legs are yellow, like the abdomen, while the eyes and the three ocelli are dark reddish brown. When 14 pupæ were measured they were found to average about 1.44 mm. in length and about 0.69 mm. in greatest width.

The orientation of the pupa is exactly the reverse of that of the host insect in the body of which it lies. Not only does the ventral surface of the parasite face the dorsum of the aphid, but the cephalic end of the *Aphelinus* is at the caudal end of its host. This latter position is occasionally reversed, however, so that the anterior ends of both insects lie in the same direction. The flat black plates of excrement will be found on the dorsal surface of the pupa's abdomen. The duration of the pupal stage is about two weeks.

EMERGENCE.

Aphelinus jucundus reaches maturity about four weeks after the egg has been laid. When ready to emerge, it gnaws a small irregular hole in the body of its host aphid. The opening is made in the dorsal wall and usually between the cornicles. When completed, it extends from the base of one cornicle to the base of the other. Occasionally emergence holes are made at the anterior end of the aphid instead of at the posterior end. In an examination of 107 aphids from which

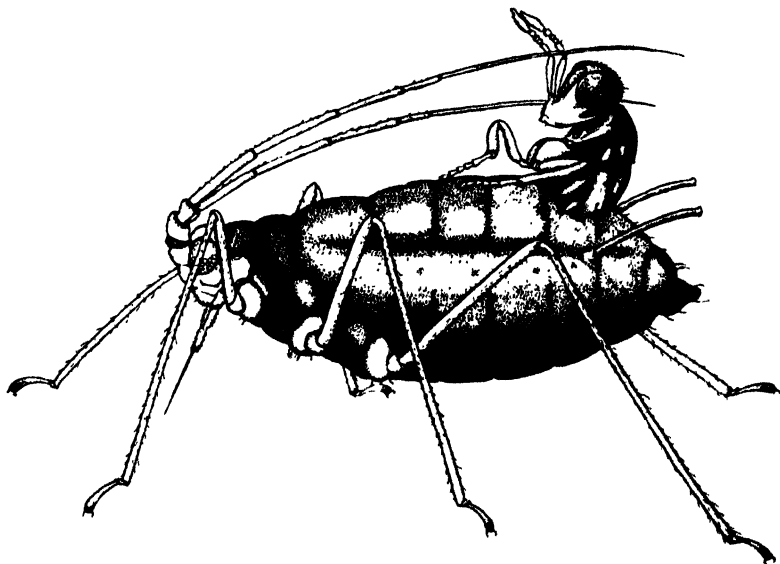


Fig. 2. Adult of *Aphelinus jucundus* Gahan emerging from a late instar nymph of *Macrosiphum cornelli* Patch. Drawn by Elizabeth K. Burckmyer.

adults of the *Aphelinus* had emerged, it was found that only in a single instance had an exit hole been made at the anterior end of the host. The remaining 106 parasites (99.06%) had emerged through openings made between the cornicles.

When the hole has reached a size sufficient to permit the passage of the chalcid's body, the head is pushed out, then the first pair of legs appears and finally the insect pulls the remainder of its body through the aperture. Knowing the day on which the eggs were laid, and knowing the length of the life cycle, the date of emergence can be determined with reasonable accuracy. By keeping specimens of parasitized aphids where,

they can be examined from time to time, chalcids just starting their exit holes may be found without difficulty. In this way it was possible to observe the act of emergence many times. It was possible also to kill specimens in cyanide before they had entirely extricated themselves (Fig. 2). Only a single adult *Aphelinus* emerged from each aphid.

HABITS.

In some ways *Aphelinus jucundus* is a rather sluggish insect. It is not readily frightened and can be easily picked from a leaf with a camel's hair brush. Or individuals can be caught in a small vial into which they will jump or crawl if the mouth of one is placed near them. When liberated on the laboratory table, they move about in a series of short hops, much like a flea. The insect is a good jumper and, under ordinary circumstances, appears to jump and crawl rather than to fly. It is, nevertheless, perfectly capable of flying when the occasion arises. The parasite is not restricted to definite parts of the greenhouse but has been found wherever the geranium aphid was present.

The oviposition habits of this chalcid are interesting. After examining an aphid with her antennæ, the *Aphelinus* steps away for a slight distance, turns around, and then backs up to her victim. The ovipositor is thrust out behind and gradually inserted into the aphid. The wings of *Aphelinus jucundus* are rather long and, when at rest, extend beyond the end of the abdomen. Hence they hinder the approach of the parasite as she backs up to her victim. To obviate this difficulty the parasite bends back the tip of her abdomen, thus folding the ends of the wings and holding them out of the way.

Feeding at oviposition holes is a common practice with *Aphelinus jucundus*. As described in an earlier paper (Griswold, 1926:331) the aphids appeared to be paralyzed by this act of the parasite and many never recovered. Further observations have confirmed the opinion previously stated, that many aphids, especially those of the earlier instars, are killed in this manner. In later work, where young aphids were placed on a leaf and exposed to this parasite for 24 to 48 hours, a number of them were always found dead when the leaf was removed from the cage.

THE SEX RATIO.

The male of this species has never been described. As far as could be observed, all of the individuals reared at the Insectary have been produced parthenogenetically and have been females. *Aphelinus jucundus* is therefore thelytokous.

EFFECT OF PARASITISM ON THE HOST.

The aphid shows no outward signs of having been parasitized until about eight or ten days after the egg of the *Aphelinus* has been laid. By this time the aphid has become more yellowish in color and the larva of the parasite can be faintly seen through the body wall of its host. Two or three days later, when the contents of the body of the host insect have been almost consumed by the parasite, the aphid gradually turns black, first on the dorsum and finally on the venter. The head, antennæ and legs, however, are pale, practically colorless. Just before this blackening occurs, the aphids are apt to crawl to some secluded spot in the fold of a leaf or under a stipule. In the breeding cages blackened aphids have often been found tucked under the edge of the cage or the bottle holding the geranium leaf, and even in a depression in the cork. The bodies of these blackened aphids appear to be fastened in some manner to the surface on which they rest, for they are not easily removed. Strands or particles of material are usually found on the ventral surface of the aphid's body. It is probable that the parasitic larva secretes some sort of silk for this purpose as described by other writers (Hartley, 1922:229; Wheeler, 1923:25).

PERCENTAGE OF PARASITISM.

The life cycle of the geranium aphid was found to be about ten days (Griswold, 1927:92) while that of the parasite is usually four weeks. For this reason it is very difficult to determine the percentage of parasitism. Yet when one sees the number of blackened aphids in the greenhouse, one realizes that *Aphelinus jucundus* is responsible for killing many plant lice.

***Aphidencyrthus inquisitor* (Howard).**

(Plate II)

This parasite belongs to the family Encyrtidæ. It was described by Howard (1881:367) and, according to Gahan, it has been redescribed several times under different names. A list of the various synonyms appears in a recent paper by Gahan (1927:18). This encyrtid has proved to be an internal secondary parasite. Several efforts were made to rear it from parasite-free aphids, but these efforts met with no success. Furthermore, upon dissecting parasite-free aphids exposed to it, none of its eggs could be found.

The egg.—The egg is oval in outline and slightly more than twice as long as broad. At one end there is a distinct stalk or pedicel. Careful measurements were made of 14 eggs. The average length (not including the pedicel) was found to be about 0.17 mm. and the average greatest width about 0.07 mm. The pedicel was found to vary considerably both in length and in position. In the 14 eggs examined the maximum length of the pedicel was 0.065 mm. and the minimum 0.029 mm. with an average length of about 0.038 mm. In some cases it extended straight out from the end of the egg, while in others it curved or went off at an angle. The egg of this hyperparasite is laid within the body of the larva of the primary parasite which is living within its host aphid. The larva of the primary parasite must have reached a certain stage in its development before the secondary parasite will deposit this egg. *Aphidencyrthus inquisitor* will not oviposit until at least two days after the egg of *Aphelinus juncundus* has hatched. If the temperature in the greenhouse for any reason is lower than usual, so that the development of the primary parasite is retarded, an even longer time must elapse. In the breeding cages two or more *Aphidencyrthus* eggs have often been laid in the same host. In one instance four eggs were found and in another six, all in a single, well developed *Aphelinus* larva. Had a greater number of host insects been available it is probable that the eggs of the hyperparasite would have been more widely distributed. The chorion of the egg is transparent so that the developing embryo within can be seen. Just before hatching, the fully formed larva, with a well segmented body, shows distinctly. As the larva is much longer than the egg in which it lies, it assumes a curved position with the cephalic and caudal ends folded back toward the middle part of the body. The duration of the egg stage is about four days.

The larva.—The first stage larva is of the caudate type. During its early larval life the insect is crescent-shaped, but as development progresses, it straightens out somewhat and the tail-like appendage is less pronounced. By the time the larva of the hyperparasite has become full-grown, nothing is left of the primary parasite but the outer body covering. The encyrtid then eats its way out of this host covering and lies directly in the blackened shell of the aphid, the entire inside of

which has already been consumed by the primary parasite. Among the hundreds of dead aphids dissected, three were found each of which contained an *Aphidencyrthus* larva partly out of the skin of its host parasite, *Aphelinus jucundus*. The larva of the hyperparasite is now more grub-like, although it still tapers somewhat toward the caudal end. After the excrement has been voided, pupation occurs. The length of the larval stage was found to be about twelve days.

The pupa.—At first the entire pupa is pale greenish yellow. Soon, however, the eyes and the three ocelli turn reddish brown and dark areas begin to appear on the dorsum of the thorax and of the abdomen. Finally the whole pupa becomes very dark, almost black, only the wing covers being slightly lighter in color. The average length of 15 pupæ was found to be about 1.1 mm. with an average greatest width of about 0.56 mm. As previously stated, the hyperparasite is now the sole occupant of the blackened shell of the dead aphid. Just as with the *Aphelinus*, the pupa of the *Aphidencyrthus* generally lies with its head at the caudal end of the aphid, but, unlike the *Aphelinus*, the venter of the encyrtid faces the venter of the insect within which it lies. The head capsule of the aphid is filled with the tiny orange ovoid pellets of excrement voided by the *Aphidencyrthus*. The pupal stage of this secondary parasite is much shorter than is that of the primary. It covers a period of from five to seven days only, thus shortening the life cycle to a period of about three weeks.

Emergence.—The adult emerges through an opening which it gnaws in the body wall of the dead aphid. The hole is smaller than that made by the *Aphelinus* and its position is not so constant. In the vials in which adults emerged, it was found that generally the hole was made at the posterior end, and that it was more commonly on the dorsum, between the cornicles. However, in many instances such openings were found on the venter. The parasite also occasionally emerges at the anterior end of the aphid. An examination of 201 aphids from which adults of this hyperparasite had emerged showed that 194 (96.5%) of the exit holes had been made at the posterior end. Of these, 116 (57.7% of the total number counted) were found on the dorsum between the cornicles, while 78 were on the venter. Of the 7 openings at the anterior end, 3 were on the dorsum, 2 on the venter and 2 on the lateral surface of the aphid. Had the aphids not been removed from the leaf, or other surface to which they were originally attached, it is probable that all of the emergence holes would have been made on the dorsum. As previously stated, the pupæ of this parasite were rarely found except with the ventral surface toward the venter of the aphid. This means that the *Aphidencyrthus*

must turn over before it can gnaw a hole in the dorsum of the aphid. Although hundreds of these parasites have been reared in individual vials, in not a single instance have two adults emerged from the same aphid.

Habits.—*Aphidencyrtus inquisitor* is a much more active insect than is *Aphelinus jucundus*. Both sexes run rapidly and are good flyers. They are also good jumpers but do not move in the series of short hops so characteristic of the *Aphelinus*. They are easily frightened, and can be caught in a vial only when approached with great caution. Before mating occurs a distinct courtship takes place. When a male is placed in a vial with a female, he may run about for some seconds without becoming aware of her presence. As soon as he discovers her, however, he is all excitement. He runs up and stands in front of her, his body swaying from side to side while he rapidly taps her antennæ with his. Then he stops these attentions and quickly runs around her, returning to his former position. Again his body sways from side to side and again he taps her antennæ with his. Then he stops and runs around her again. These antics may be repeated any number of times. In one instance a little male went through this performance thirty-three different times before copulation took place.

When ready to oviposit, the female mounts the aphid, which she examines with her antennæ. Then the ovipositor is gradually pushed downward and slightly backward into the aphid. The parasite's wings are folded on her abdomen, while her antennæ are held close to her head. While oviposition is going on, the *Aphidencyrtus* is less easily disturbed than at any other time.

Feeding at oviposition holes is as common a practice with the female of this species as it is with the primary parasite, *Aphelinus jucundus* (Griswold, 1926:331). In this case, however, the habit has no injurious effect on the aphids. After aphids have been placed on a leaf and exposed to this parasite, all of them will generally be found alive when the leaf is removed from the cage.

The sex ratio.—The antennæ of the two sexes are so different that the insects were at first thought to be two distinct species. For this reason, from the very beginning, accurate records

were kept of the number of males and females reared. Of 111 individuals reared from aphids taken at random in the greenhouse, 58% were males and 42% females. Later some careful rearing experiments were carried on with the distinct purpose of determining the sex ratio. Only females that were seen to mate were placed in the rearing cages. From these cages were eventually reared 833 individuals of which 442 (53%) were found to be males and 391 (47%) females. When *Aphidencyrus inquisitor* reproduces parthenogenetically the species was

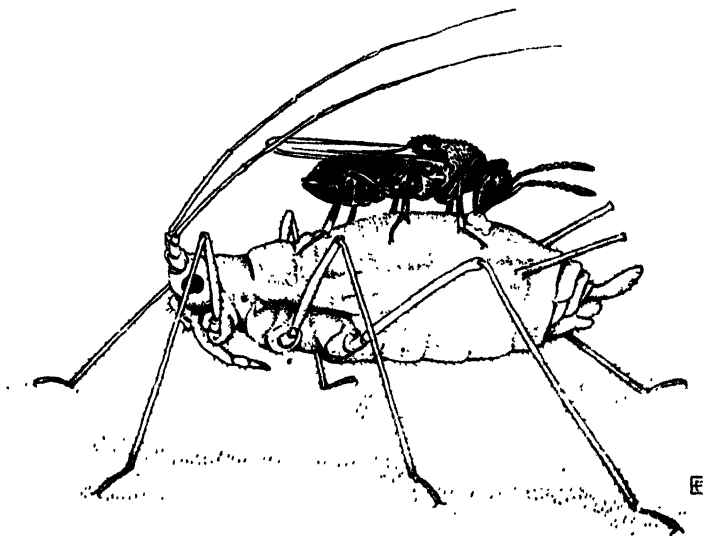


Fig. 3. Female of *Aphidencyrus inquisitor* (How.) feeding at an oviposition hole made in the abdomen of *Macrosiphum cornelli* Patch. Drawn from living specimens by Ellen Edmonson.

found to be arrhenotokous. In the breeding cages unmated females laid eggs from which were eventually reared 167 individuals, all of which were males.

Percentage of hyperparasitism.—In an effort to get some idea of the percentage of hyperparasitism, 298 blackened aphids were collected at various times at random in the greenhouse and placed in individual vials. From these aphids were eventually reared 257 parasites. Of these, 69% were *Aphelinus jucundus* and 31% were the secondary parasite, *Aphidencyrus inquisitor*. By destroying *Aphelinus* larvæ the *Aphidencyrus* prevents the increase and spread of a beneficial species of primary parasite.

***Asaphes americana* Girault.**

(Plate III)

This parasite, which was described by Girault (1914:114) belongs to the family Pteromalidæ. It has proved to be both a secondary and a tertiary parasite. In its larval stage it feeds externally on its host when the host is living in the blackened shell of the dead aphid. Its larvæ have been found feeding not only on the larvæ of the primary parasite, *Aphelinus jucundus*, but also on the larvæ and on the pupæ of the secondary parasite, *Aphidencyrthus inquisitor*, when these were lying free in the blackened shells of aphids. As was done with the *Aphidencyrthus*, an effort was made to rear the *Asaphes* from parasite-free aphids. This met with no success, nor would this parasite oviposit in parasitized aphids until the latter had turned black.

The egg.—The egg is pearly white in color and oval in outline, although it is somewhat more rounded at the anterior than at the posterior end. Upon measuring 10 eggs they were found to average about 0.25 mm. in length and 0.1 mm. in width. The egg is laid on the outside of the host parasite which is living in its host aphid. Usually the host selected is in the mature larval stage, however, in some instances eggs were found on host pupæ. Generally but one egg is placed on an individual host but in one instance three eggs of *Asaphes americana* were found on a single larva of *Aphelinus jucundus*. Just before hatching, the segmented larva of the *Asaphes* can be distinctly seen within the egg. The egg stage of this hyperparasite is about four days.

The larva.—The early instar larva is more or less top-shaped, the anterior end being quite blunt while the posterior end tapers somewhat. As development progresses, the caudal end fills out and finally the larva becomes crescent-shaped, thus differing entirely from the larvæ of the other two parasites under discussion. Although the color is yellow, it is of a much paler shade than that of the larvæ of either *Aphelinus jucundus* or *Aphidencyrthus inquisitor*. By the time the larva has become full-grown its host has been consumed, so that the *Asaphes* remains the sole occupant of the blackened shell of the dead aphid. After the excrement has been voided, pupation occurs. The length of the larval stage in this species is about eleven or twelve days.

The pupa.—The newly formed pupa is pale yellow in color, but soon the eyes become brownish-orange, then the body gradually darkens until it has become almost black. The pupa, like the larva, is crescent-shaped and lies on its side in the body of the dead aphid. About the caudal end will be found the excrement in the form of tiny black ovoid pellets. The length of the pupal stage is about five or six days. Thus the entire life cycle extends over a period of approximately three weeks.

Emergence.—The adult *Asaphes* emerges from the aphid in a manner similar to that employed by the other two parasites under discussion. The location of the emergence hole is even less constant than in the case of *Aphidencyrthus inquisitor*. This is possibly due to the fact that the *Asaphes* pupa lies on its side within the dead aphid instead of on its venter, as does the *Aphidencyrthus*. In an examination of 199 aphids from which adults of *Asaphes americana* had emerged, it was found that 165 (82.9%) had gnawed holes at the posterior end. Of these, 122 (61.3% of the total number counted) were on the dorsum between the cornicles, 25 were on the venter, and 18 on the lateral surface of the aphid. Of the 34 holes made at the anterior end, 27 were on the dorsum and 7 on the venter. As with the other two parasites discussed, only a single adult has been found to emerge from each aphid.

Habits.—*Asaphes americana* was found to be an active insect and a good flyer, but no detailed notes were taken as to its favorite manner of locomotion. In this species there is also a sort of courtship before mating occurs, although it is not as marked as in *Aphidencyrthus inquisitor*. The male jumps on the back of the female and stands there while she walks about. His middle and hind legs rest on her wings, while with his front legs he grasps her eyes. In the breeding cages females with males perched on their backs in the manner just described, were often seen walking about on the geranium leaves, or on the sides of the cage. Actual mating was not observed at the Insectary but Spencer (1926:146) says it "occurs as soon as the female is dry." He also describes in detail the act of oviposition in this species.

The female *Asaphes* was never seen feeding at puncture holes made by the ovipositor and very probably lacks this habit, which proved to be so common with *Aphelinus jucundus* and with *Aphidencyrthus inquisitor*. Observations made at the Insectary indicated that the female *Asaphes* was not interested in living aphids, but only in those which were dead, and had turned black. As previously stated, it was in black aphids only in which she was found to deposit her eggs.

The sex ratio.—The two sexes are not as easily differentiated as those of *Aphidencyrthus inquisitor*. The abdomen of the female *Asaphes* is more pointed than is that of the male, and the ovipositor can be plainly seen on the ventral surface.

There is also a slight difference in the antennæ. The males of this species are more prevalent than are the females and this condition made the breeding work difficult. Of 40 individuals reared from parasitized aphids taken at random from the greenhouse, 72.5% were males and 27.5% were females. An attempt was made to carry on some rearing experiments to determine the sex ratio in *Asaphes americana*. As previously explained, mating was not observed in this species but the preliminary courtship was a common occurrence. Only couples which were seen to engage in this courtship were admitted to the breeding cages, and then only after they had remained together for some hours in the vials in which the courtship had taken place. From these breeding cages were reared 193 individuals, of which 158 (82%) were males and 35 (18%) were females. This species also reproduces parthenogenetically and was found to be arrhenotokous. Eggs laid by unmated females produced 79 males and no females.

Percentage of hyperparasitism—No studies were made on the percentage of hyperparasitism in *Asaphes americana*. As this species was found to be both a secondary and a tertiary parasite, it must be considered both a beneficial and an injurious insect, depending upon the status of the host attacked. According to Muesebeck and Dohanian (1927:4) "it is doubtful if any species are obligatory tertiary parasites." It has been proved by these studies that *Asaphes americana* is not such a parasite.

CONCLUSIONS.

As one studies parasites—primary, secondary, tertiary—one wonders if the end of parasitism is ever reached. Surely *Asaphes americana* must have its parasitic enemies, while these in turn must have theirs. As long as the blackened shell of the dead aphid remains intact, why should this not serve as a home for one parasitic larva after another, each of which devours its predecessor only in turn to be itself devoured? This may all be true but it would be difficult to prove.

SUMMARY.

Aphelinus jucundus is an internal primary parasite, *Aphidencyrus inquisitor* is an internal secondary parasite, while *Asaphes americana* is both an external secondary parasite and an external tertiary parasite.

The egg, larval, and pupal stages of all three chalcids are spent within an aphid which is the true host of the *Aphelinus* only. As they differ in every phase of their development, no trouble was experienced in recognizing each species no matter in what stage it was found.

The adult of each of the three species emerges through a hole gnawed in the body wall of the dead aphid. The hole is more commonly on the dorsal surface, between the cornicles.

With both of the hyperparasites there is a preliminary courtship before mating occurs.

Feeding at oviposition holes is a common practice with *Aphelinus jucundus* and with *Aphidencyrthus inquisitor* but not with *Asaphes americana*.

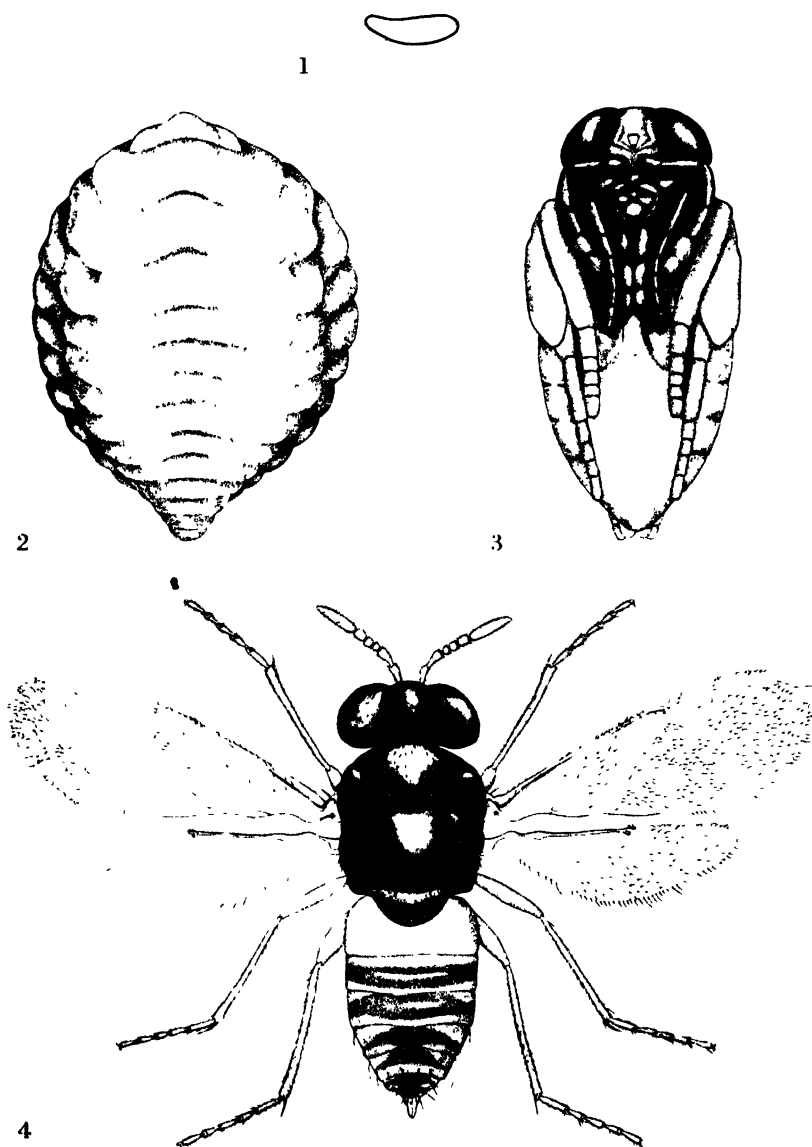
Aphelinus jucundus appears to reproduce by parthenogenesis only, all of the progeny being females. *Aphidencyrthus inquisitor* reproduces both sexually and parthenogenetically. With sexual reproduction, males are slightly more common than are females. The progeny of unmated females are all males. In *Asaphes americana*, males are much more common than are females, while unmated females were found to produce only males.

The life cycle of *Aphelinus jucundus* is four weeks while that of the aphid is ten days. This lack of adjustment of the parasite to its host makes it difficult to determine the percentage of parasitism. Both *Aphidencyrthus inquisitor* and *Asaphes americana* have life cycles of about three weeks. Therefore the hyperparasites are better adjusted to their hosts than is the primary parasite to its host aphid.

Aphelinus jucundus is a beneficial parasite while *Aphidencyrthus inquisitor* is an injurious one. *Asaphes americana* is either beneficial or injurious, depending upon the status of its host.

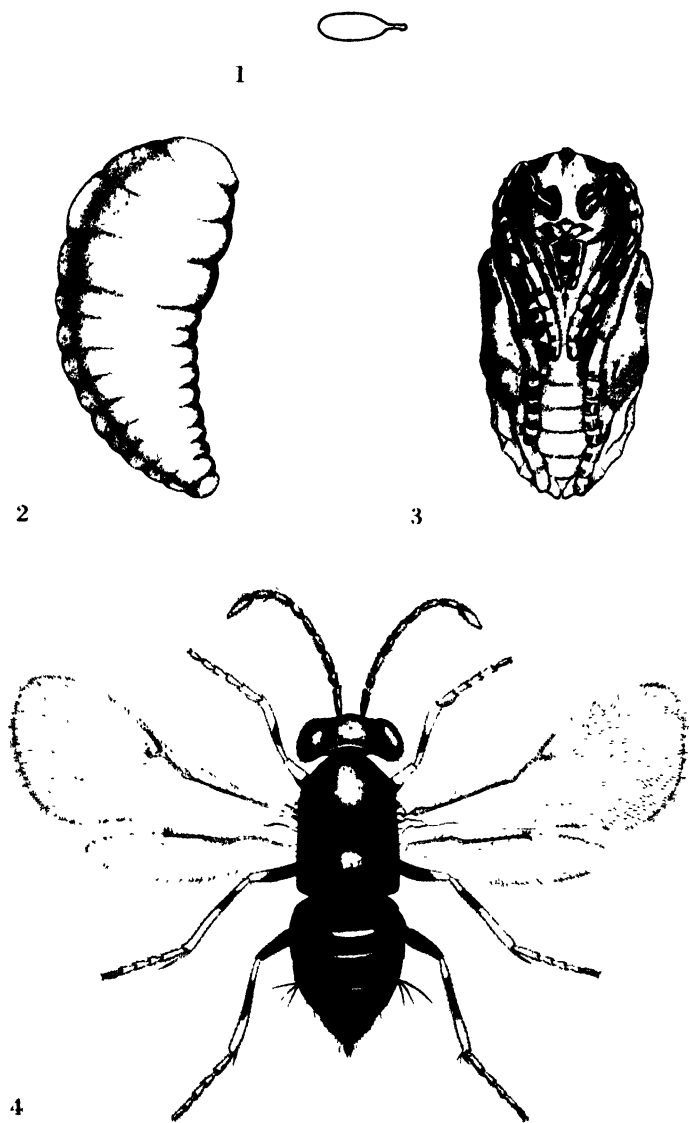
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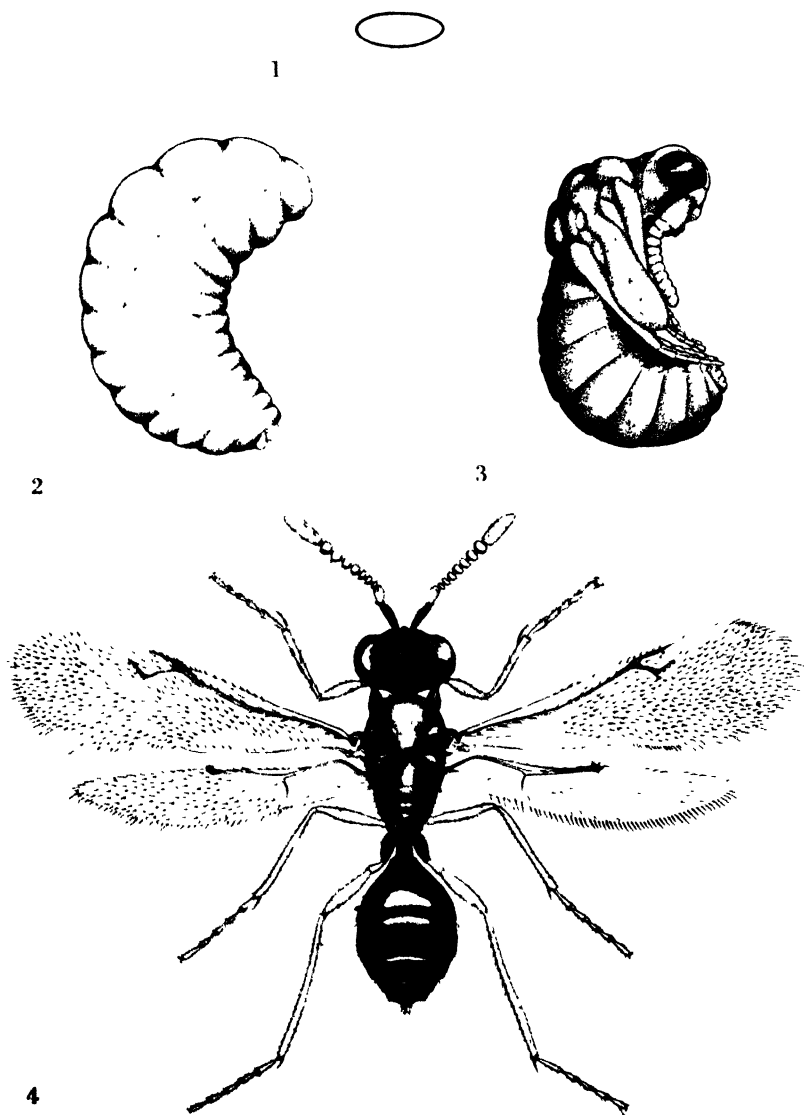
Aphelinus jucundus Gahan.

Fig. 1, Egg; Fig. 2, Mature larva, Fig. 3, Pupa, ventral view; Fig. 4, adult female.



Aphidius inquisitor (How.)

Fig. 1. Egg; Fig. 2. Mature larva, lateral view; Fig. 3. Pupa, ventral view;
Fig. 4. Adult male.



Asaphes americana Girault.

Fig. 1, Egg; Fig. 2, Mature larva, lateral view; Fig. 3, Pupa, lateral view;
Fig. 4, Adult male.

NOTES ON THE NATURAL ENEMIES OF THE IRIS BORER, *MACRONOCTUA ONUSTA* GROTE (LEPIDOPTERA).

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Little is known concerning the natural enemies of the Iris borer, *Macronoctua onusta* Grote. Dietz (1) records two species of Hymenoptera that were found to be parasitic on the larvæ of this pest, and his record seems to be the only one that has been made. As several entomologists and the Iris growers themselves are interested in the biological control of the borer, the writer has been urged to record some observations he has made on its natural enemies. An unusually heavy infestation of the Iris borer of several years standing was under observation. Evidence is at hand to show that the caterpillars are attacked by a number of predaceous and parasitic insects, and that they are further reduced in numbers by insectivorous birds and rodents. The relations between the habits of this insect and its enemies will be more clearly understood if a brief résumé of its seasonal activities is presented.

Macronoctua onusta has but one generation a year, winter being passed in the egg stage. The moths emerge in late summer and soon begin depositing their eggs. The eggs are inserted in folds and crevices that occur in either the dead and discolored remains of the Iris plants or in those of other plants which may be present in the immediate vicinity. With the coming of warm weather in the spring, the eggs hatch and the young caterpillars seek the tender foliage of the host plant where they begin leaf-mining activities. At this early stage they will often abandon their burrows and wander about over the leaves. As development proceeds, the leaves, especially their edges, will be made quite ragged by the internal feeding of the caterpillars. Their activities soon take them down among the ensheathing lower halves of the leaves where they remain until nearly half grown before attacking the rhizomes. Often instead of penetrating the heart of the rhizome the caterpillar will eat out a deep channel along its side. Many of the caterpillars were observed to go from one rhizome to the next, and

often would severely injure if not destroy several before reaching maturity. It will be seen that the activities of the caterpillars may contribute to their being parasitized by such flies as the Sarcophagids and Tachinids.

The caterpillars are gross feeders and produce a large amount of wet excrement which accumulates in the burrows. Such an accumulation furnishes an excellent medium in which numerous organisms are sure to develop. Bacteria and fungi become active and help produce evil smelling products of decay. Dipterous larvæ were noted to be present in numbers. Doubtless the majority of these were scavengers, but such conditions would aid larvæ with habits such as those of *Muscina stabulans* to reach the caterpillars in whose bodies they are able to live as parasites.

Early in August, when larval development was nearing completion and pupation had begun, one hundred caterpillars of *Macronoctua onusta* were collected and placed in breeding cages. Care was exercised to avoid injuring the specimens. Three or four inches of clean moist sand had been lightly packed in the bottom of each cage, and in this the caterpillars were able to construct their pupal chambers much as they do in the earth near the host plant. The cages were left outside and developments watched with interest, as a census of the species that might be parasitic on the caterpillars was much desired.

DIPTERA.

The first Diptera appeared on September 1 and the last on September 10, the first moths emerging on the latter date. There was an indicated parasitism of ten per cent. In each instance the host had apparently been destroyed just before pupation, the puparium of the fly lying in the sand in the immediate vicinity. The following species issued from the caterpillars of *Macronoctua onusta*: *Muscina stabulans* Fall., *M. assimilis* Fall., *Myiospila medilabunda* Fab. (Muscidæ); *Sarcophaga cimbicis* Tns., *S. latisterna* Park. (Sarcophagidæ); and *Masicera semilis* Mg. (Tachinidæ). This opportunity is taken for thanking Dr. J. M. Aldrich, of the U. S. National Museum, for his services in making known the identity of the Diptera.

For the purpose of indicating to what extent each species may be considered a natural enemy of *Macronoctua onusta*, the following citations are presented.

***Muscina stabulans* Fall.**

More specimens of *Muscina stabulans* were secured than of any other Diptera. A review of the literature reveals that the larvæ of *M. stabulans* are nearly omnivorous, that they are predaceous, and that they do become parasitic. Portchinsky (6) found that the larvæ are predaceous on those of other Muscids and grow very quickly on this live diet, that they are not cannibalistic, and that they are scavengers, living in decaying animal and vegetable matter. When he fed them fresh dead flies and other insects they bored into the bodies and ate the contents. Graham-Smith (2) also found them to be predaceous on the larvæ of other Diptera. He observed that the larvæ, especially in the later stages, tend to migrate, even though the food supply is abundant. Herold (3) bred *M. stabulans* from *Euxoa segetum* Schiff. and mentions that prior to this no Diptera had been bred from this host. Rodionov (7) bred *M. stabulans* from pupæ of the corn ear-worm, *Heliothis obsoleta* Fab.

***Muscina assimilis* Fall.**

The larvæ of this fly are very similar in habits to those of *M. stabulans*. Keilin (4) describes them as semi-carnivorous or omnivorous, as they can maintain life in the absence of animal matter upon vegetable matter in a state of decomposition. He states that they are frequently found in decaying fungi and other vegetable matter, where they live upon the larvæ of such Diptera as *Drosophila confusa*, *Fannia canicularis* L., and *Aphiochaeta rufipes* Mg.

***Myiospila meditabunda* Fab.**

The habits of the larvæ of this species resemble the former in many respects. Portchinsky noted that they are cannibalistic when other food is scarce. Keilin found them to be carnivorous, feeding on the larvæ of Sarcophagids as well as those of certain Anthomyiids and Borborids which accompanied them.

***Sarcophaga cimbicis* Tns.**

The Sarcophagids are well known parasites of other insects. The known hosts of *Sarcophaga cimbicis* are from such diverse orders as the Orthoptera, Coleoptera, and Lepidoptera, and

include the Grasshoppers, the *Phyllophaga*, the green clover worm, *Plathypena scabra* Fab., and the cankerworm, *Alsophila pometaria* Harr.

Sarcophaga latisterna Park

Sarcophaga latisterna has been recorded as a parasite of several Lepidoptera. It seems to be more selective in the choice of hosts, apparently confining itself to the one order. Some of the known hosts are *Heliothis obsoleta*, *Alsophila pometaria*, and the cabbage butterfly, *Pieris rapæ* L.

Masicera senilis Mg.

Specimens of this species made their appearances on September 9 and 10. All other Diptera had emerged on September 1. In point of numbers appearing it ranks next to *M. stabulans*. Thompson, W. R. and Thompson, M. C. (8) in a paper dealing with the taxonomy and biology of *Masicera senilis* state that "it seems probable that *myoidea*- or *radicis*- is taxonomically identical with *senilis*, although biologically the two forms may perhaps be distinct." In Southwestern France, *M. senilis* has two generations a year and is in both generations a parasite of the European corn borer, *Pyrausta nubilalis* Hubn. The period of hibernation is passed in the second larval stage in the hibernating caterpillars of the host. Thompson and Parker (9) found that in the laboratory the larvæ of *M. senilis* were deposited on the leaves on which the young caterpillars of the host were feeding, and that the parasite larvæ, instead of lying in wait for their hosts, started out in search of them. The American homonym seems to be a common parasite of Lepidopterous stem borers. Lowry (5) states that *M. senilis* was by far the commonest parasite bred from larvæ of the common stalk borer, *Papaipema nebris* Gn. during the three years of his study of that pest in New Hampshire and accounted for over half of the parasitism.

HYMENOPTERA.

No Hymenoptera issued from the caterpillars under observation. Dietz reports two species, *Apanteles militaris* Walsh. (*Braconidæ*) and *Amblyteles jucundus* Brulle (*Ichneumonidæ*) as being parasitic on *M. onusta* in Indiana. *Apanteles militaris* is known as a gregarious parasite of the army worm, *Cirphis*

unipuncta Haw., and *Amblyteles jucundus* is known to be parasitic on *Papaipema* larvæ.

PREDACEOUS COLEOPTERA.

Both the larval and adult stages of *Calosoma* were encountered while conducting these investigations. *Calosoma calidum* Fab. was most frequently seen. While *Calosoma* larvæ were not observed to attack the caterpillars of *M. onusta* in the field they did not hesitate to do so in captivity.

BIRDS.

On one of the visits to the Iris plantings the writer and a nursery inspector saw a female robin, *Planesticus migratorius migratorius* L., collecting caterpillars from near the infested plants. As it was possible to approach to within a short distance of the bird we were able to convince ourselves that the caterpillars were those of *M. onusta*. A recent cultivation may have disturbed the borers and made their discovery the easier.

RODENTS.

Shortly after pupation had begun it was observed that some small insectivorous rodents had discovered the larvæ and pupæ present in numbers and were making the Iris plantings their feeding grounds. A rain early the night before tended to obliterate disturbances in the earth's surface and made the recent diggings of the little mammals the more conspicuous. That they were after larvæ and pupæ was quite obvious, for many times their excavations revealed opened pupal chambers from which the occupants had been extracted.

SUMMARY.

1. An unusually heavy infestation of the Iris borer of several years standing was under observation.

2. The following Diptera were bred from caterpillars of *M. onusta*: *Muscina stabulans* Fall., *M. assimilis* Fall., *Myio-spila meditabunda* Fab., *Sarcophaga cimbicis* Tns., *S. lalisterna* Park., and *Masicera senilis* Mg.

3. There was an indicated parasitism from Diptera in 1928 of ten per cent.

4. In number of individuals appearing *Muscina stabulans* ranked first and *Masicera senilis* second.

5. The host had apparently been destroyed in each instance just before pupation, the puparium of the fly lying in the immediate vicinity of the pupal chamber.

6. The leaf feeding activities of the young caterpillars may contribute to their being parasitized by the larvæ of *Masicera senilis*.

7. The filthy conditions under which the caterpillars live obviously contribute to their being parasitized by larvæ with habits such as those of *Muscina stabulans*.

8. The activities of the caterpillars expose them to the attacks of such parasitic Diptera as the Sarcophagids.

9. No Hymenoptera issued from the caterpillars under observation.

10. Predatory enemies of *Macronoctua onusta* include the larval and adult stages of *Calosoma*, of which *C. calidum* Fab. was the most common; the robin, *Planesticus migratorius migratorius* L.; and insectivorous rodents.

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A NEW GENUS AND THREE NEW SPECIES OF SOUTH AMERICAN CICADELLIDÆ (HOMOPTERA).

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The species described below are so distinct from other Cicadellidæ and form as a group so well marked an assemblage that I feel warranted in placing them in a new genus. Types of new species in the author's collection.

Genus *Idiotettix*.

The shape of *Idiocerus* but with ocelli well up on the border between vertex and front, with some resemblance to *Cicadella* of the short vertex forms. Head very broad; eyes conspicuous extending distinctly beyond borders of pronotum; vertex short, scarcely as long at middle as next the eye; front broad, nearly as wide as long; clypeus expanding toward the apex; pronotum strongly arched in front, lateral border short; scutellum large; elytra elongate, extending beyond tip of abdomen, narrowing to the apex with a distinct appendix; veins rather obscure; clavus without cross nerves.

Type of the genus, *Thamnotettix magnificus* Osb.

Idiotettix magnificus Osb.

Thamnotettix magnificus Osborn. Annals of the Carnegie Museum, Vol. XV, 1924, p. 424.

The type specimen was a female from Quatro Ojos, Bolivia, in the Carnegie Museum collection. A male from the author's collection which agrees in all general characters with the female has the last ventral segment short, scarcely as long as the preceding, valve hidden or wanting; the plates apparently fused at base, apical two-thirds bearing short stiff bristles and the apex narrowed, acute, upturned and reaching end of pygofer.

The colors are possibly slightly darker, but correspond in picture with the female as described. The female is 12 mm.; male 9.5 mm. in length. The male was collected by H. S. Parish, Bartica, British Guiana, March 20-30, 1901. This species was doubtfully referred to the genus *Thamnotettix* with the note that it bore a strong resemblance to some members

of the genus *Cicadella*. Since the publication of that description, I have received specimens of three other species which, taken together, form a group which seem to me to warrant the forming of a new genus. Their exact affinities seem still problematic, since they possess features which taken by themselves might connect them with *Idiocerus*, *Cicadella* or perhaps more pronouncedly with *Thamnotettix*, although they do not agree well with any group within any one of these genera. The position of ocelli will exclude them from either *Bythoscopinæ* or *Cicadellinæ* and place them in *Jassinæ*, but in size and elytral patterns they seem rather to belong to *Cicadella* than to *Thamnotettix*.

***Idiotettix boliviana* n. sp.**

Head broad, much wider than pronotum, eyes almost protruding; vertex very short, scarcely as long at middle as next the eye; ocelli on the border between vertex and front, much nearer to the eye than to each other, about twice the diameter from the eye; front longer than wide, borders curving towards base of clypeus; clypeus twice as long as width at base, widening toward tip; loræ elongate. Pronotum polished, faintly rugose, lateral border reduced to a point, lateral angles broadly rounded, hind border slightly concave.

Vertex with a broad orange red band behind the ocelli and another below the ocelli on base of front which has, lower down, two broad browish cross bands. A line between the ocelli is luteus and two bands, and the apex on front are pale yellowish; the antennal pits and a broad line on suture between front and cheek jet black; clypeus and loræ pale yellowish, slightly tinted with brownish on the central part; pronotum, scutellum, and elytra mostly brown, tinged with reddish or chocolate. A row of spots next to commissure and the claval suture at base and toward tip milky hyaline. Along center of elytra and apical areoles mostly yellow, base of outer cell with three spots on the central apex, reddish. Beneath dull yellowish, with spot on the propleura and sternum and the tarsi, black or brownish.

Described from a single specimen (holotype), Coroico, Bolivia, received from a European dealer.

***Idiotettix fasciatus* n. sp.**

Head broad, distinctly wider than pronotum; vertex short, margins nearly parallel; ocelli less than twice their diameter from the eye; front long, slightly convex; clypeus twice as long as wide; loræ elliptical almost touching margin of cheek. Pronotum short, hind border slightly concave; scutellum smaller than in *boliviana*; apex acute; clavus with two distinct veins, the anterior one quite short.

General color fulvous, a broad fulvous band above and below ocelli and two stripes tapering toward apex on the front; front dull yellowish with nine or ten dark lateral arcs; pronotum with four broad longitudinal stripes and the border fulvous; scutellum brown on the disk with a V-shaped black mark margined by yellowish, the lateral borders fulvous; elytra brown fulvous with a velvety texture, with claval and discal veins of elytra dark purplish margined with blackish; outer half of elytra with five irregularly shaped whitish spots margined with fuscous, apical areas fuscous, center of tip and part of apical veins whitish; beneath pale yellow, tips of tarsi dark. Length 8 mm.

Described from two specimens, one (holotype) Hohenau, and the other (allotype), Villarica, Paraguay. These are slightly smaller than *boliviana* and differ from that species very distinctly in the conspicuous stripes of the pronotum.

***Idiotettix brunneus* n. sp.**

Head distinctly wider than pronotum, vertex short considerably shorter at middle than next the eye, ocelli near the eye, scarcely more than the diameter from the margin; front long, tapering with slight curvature to base of clypeus; clypeus more than twice as long as width at base, apex rounded; loræ elongate, the outer margin paralleling very closely the margin of the narrow cheek. Pronotum short, lateral angles broadly rounded, hind border scarcely concave; scutellum wider than long; elytral veins fairly distinct. Color uniformly brown with arcs, on the front, faint stripes on the pronotum, the elytral veins and borders to faintly defined milky spot on outer half of elytra, fuscous. Length 7 mm.

Described from a single specimen (holotype) received from a European dealer and labeled Hohenau, Paraguay.

FIVE NEW APHIDIDÆ FROM COLORADO.

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This paper deals with four new species of the subtribe *Macrosiphina* and one of the subtribe *Aphidina*.

Acknowledgments are due to Dr. P. W. Mason for examination and opinions concerning these forms.

Macrosiphum williamsi, n. sp.*

Apterous summer viviparous female.—(Plate I, Fig. 1; Plate II, Figs. 1, 3 and 4). Described from type and 6 paratypes taken on *Lactuca* sp. in foothills near Fort Collins, Colo., May 30, 1916, by L. C. Bragg.

Color: Brick-red, shining, becoming lighter on pronotum, head and terminal body segment; cauda pale yellow; legs pale yellowish except knees, distal ends of femora and tibiæ and entire tarsi, which are dusky to black; antennæ dusky except base of joint III, which is pale; cornicles black.

Measurements: Body to base of cauda, 2.50 mm. when alive (2 mm. after being mounted); hind tibiæ 1.70 mm. (1.66 to 2 mm.); antennæ 2.70 mm. (2.50 to 3 mm.); joints: III, 1.08 mm. (1 to 1.12 mm.); IV, .33 mm. (.32 to .38 mm.); V, .30 mm. (.30 to .33 mm.); VI, .10 mm. + .80 mm. (.75 to .80 mm.); cornicles, .50 mm. (.45 to .50 mm.); cauda, .40 mm.†

Structural characters: Secondary sensoria on joint III only, about 71 in number; hairs on body blunt or slightly capitate, short, .04 mm. in length and sparse; on cauda slightly curved, pointed, .08 mm. long and 6 or 7 on a side; on legs blunt, .04 mm. long and moderately numerous; on antennæ slightly capitate, barely attaining diameter of joint in length; cornicles cylindrical or slightly tapering, with closed reticulations on distal one-fourth, remainder imbricated, distinct flange present; cauda acute conical with slight constriction near base; frontal tubercles distinct and diverging; lateral tubercles not evident; ocular tubercles present.

Alate viviparous female.—(Plate I, Fig. 2; Plate II, Fig. 2). Described from type and 11 paratypes taken on *Lactuca* sp. in foothills near Fort Collins, Colorado, May 30, 1916, also 7 other paratypes taken June 2, 1916, all by L. C. Bragg.

Color: Brick-red on abdomen, lighter on thorax and head; cauda pale yellow; legs pale yellow except knees, distal ends of femora and

*Measurements in parentheses refer to range of variation in paratypes.

†Measurements of caudæ include both hard and soft portions.

tibiae and entire tarsi black; antennae dusky throughout; cornicles black; stigmas brownish-yellow.

Measurements: Body, to base of cauda, 2.17 mm. alive (2 mm. in balsam mount); hind tibiae, 2 mm. (1.70 to 2 mm.); antennae, 2 mm.; joints as follows: III, 1.34 mm. (1.10 to 1.35 mm.); IV, .36 mm. (.33 to .42 mm.); V, .38 mm. (.30 to .40 mm.); VI, .12 + .93 mm. (.76 to .93 mm.); cornicles, .50 mm. (.43 to .52 mm.); cauda, .30 mm.

Structural characters: Secondary sensoria on joint III, 91; IV, 2 on one antenna and 6 on the other (2 to 6); other joints without secondary sensoria; hairs blunt or slightly capitate, on body .03 or .04 mm. in length, rather sparse; on antennae similar; on legs similar or slightly longer and more numerous; on cauda pointed and somewhat curved, 5 or 6 on a side; cornicles cylindrical, slightly broader at base, with closed reticulations on distal one-fourth with distinct flange; cauda acute, with slight constriction near base; frontal tubercles distinct and diverging; fore wings with mediae twice branched; hind wings with both cross veins present.

Collections were taken from *Lactuca* sp. in foothills near Fort Collins, Colorado, Altitude 6,000 to 7,000 feet, by L. C. Bragg, as follows:

Apterous viviparous female.—Two collections, May 30 and July 6.*

Alate viviparous female.—Two collections, May 30 and June 2.

Types in United States National Museum, (Slides No. 41924); paratypes in collection of Colorado Agricultural Experiment Station.

This species is very close to *Siphonophora muralis* Buckton, but differs from Buckton's description in following cornicle measurements: For *muralis*, 1.27 mm. in apterous and .76 mm. in alate viviparae, as compared with .50 mm. in both apterous and alate viviparae in *williamsi*. According to Theobald's description* sensoria differ as follows on third joint of antennae for *muralis*, 25 to 28 in apterous and 30 to 35 in alate as compared with 71 in apterous and 91 in alate of *williamsi*.

The species is named after T. A. Williams, who first described it, though under the name of *Siphonophora muralis* Buckton.†

This species seems to closely resemble *Macrosiphum sonchi* L. It seems to differ in that *sonchi* seems to have considerably fewer sensoria on antennal joint III and none on joint IV in alate; cornicles are more long and slender. The food plant seems also to differ as *sonchi*, though reported from quite a number of hosts, is apparently not recorded from wild *Lactuca*.

*A collection of apterous viviparae belonging to this species was taken at Newton, Kansas, October 11, 1914, by the Senior author.

†Theobald, F. V., *The Aphididae of Great Britain*, 1: 93.

‡Williams, T. A., *The Aphididae of Nebraska*, Apr. 1910. 83. (Univ. Studies, 10: 2, 83). See also Davis, J. J. Williams, "The *Aphididae* of Nebraska," A Critical Review (Univ. Studies, Lincoln, Nebraska, 11: 3, p. 31, 1911).

This species may seem to bear a resemblance to *Macrosiphum lanceolatum* Patch on *Solidago*, especially in regard to color, but it differs decidedly in the ratio of antennal joints ("45, 38, 35, 10 + 55" in Patch's species, and 100, 32, 32, 11 + 75 in ours), and in the number of sensoria on joint III (alate viviparæ 30, and apterous viviparæ 20 in Patch's, and 91 in alatae and 71 in apterae in our species).

***Myzus leucocrini* n. sp.**

Apterous summer viviparous female.—(Plate I, Fig. 3; Plate II, Figs 5 and 6). Described from type and 16 paratypes taken on *Leucocrinum montanum*, near Fort Collins, Colorado, May 26, 1916, 9 others from May 6 to May 19, all by L. C. Bragg.

Color: Immature and freshly matured individuals are light green with a conspicuous rusty blotch about the base of each cornicle; cornicles pale on proximal half and blackish on distal half. Old adults appear black or very dark green or greenish-brown with tip of abdomen pale greenish and with rusty coloration at bases of cornicles; cauda pale yellowish; legs very pale, except for distal two-thirds of femora, which are slightly dusky, and tarsi and tips of tibiae, which are black; antennae are slightly dusky except base of joint IV and almost entire III, which are very pale; cornicles dusky, especially distally.

Measurements: Body* to base of cauda, 1.75 mm.; hind tibiae, 1 mm.; antennae, 1.60 mm.; joints as follows: III, .38 mm. (.33 to .40 mm.); IV, .28 mm. (.24 to .29 mm.); V, .25 mm. (.24 to .30 mm.); VI, .12 mm. to .36 mm. (.34 to .41 mm.); cornicles, .40 mm.; cauda, .15 mm.

Structural characters: Secondary sensoria absent on antennae; hairs blunt, minute, on body practically invisible; on antennae, hardly .01 mm. in length, and sparse; on tibiae similar, but slightly longer, over .01 mm., more pronounced on the inner margin; on cauda pointed, curved and about .04 mm. long, and about 5 on a side; cornicles peculiar in shape, outer margin slightly curved inward, inner side curving from a broader base to form more slender middle portion, then curving to form slight swelling at distal end, flange distinct, cornicle imbricated; cauda blunt, almost parallel sided, with slight constriction near base; frontal tubercles pronounced, with tendency to convergence; ocular tubercles present; surface of body marked with reticulations which are distinct though not frosted.

Alate viviparous female.—(Plate I, Fig. 4; Plate II, Figs. 7, 8 and 9). Described from type and numerous paratypes taken on *Leucocrinum montanum* near Fort Collins, Colorado, May 6 to 28, 1916, by L. C. Bragg.

Color: Abdomen, head and pronotum light green, meso- and meta-thorax black, head and pronotum tinged with dusky, abdomen with lateral spots and dorsal dashes of dusky or dark green; areas at bases of cornicles tinged with orange; antennae, legs and cornicles pale to color-

less, except tarsi, tips of tibiæ, cornicles and antennal joints III, IV, and V, and entire VI dusky to black; in older examples entire cornicles and tibiæ are entirely black or blackish; cauda pale greenish or slightly dusky; stigmæ yellowish-brown; veins of fore and hind wings narrowly bordered with brownish to black.

Measurements: Body, 1.60 mm. to base of cauda; hind tibiæ, .83 mm.; antennæ, 1.60 mm.; joints as follows: III, .37 mm. (.34 to .40 mm.); IV, .28 mm. (.26 to .30 mm.); V, .26 mm. (.25 to .29 mm.); VI, .12 mm. + .41 mm. (.41 to .47 mm.); cornicles, .26 mm. (.25 to .38 mm.); cauda, .12 mm.

Structural characters: Secondary sensoria on joint III only, 8 and 9 in number (6 to 11); all joints heavily imbricated; hairs, cauda, and cornicles as in apterous viviparæ; fore wings with mediæ twice forked; hind wings with 2 cross veins.

Collections were taken on *Leucocrinum montanum*, at Fort Collins, Colorado, by L. C. Bragg, as follows:

Apterous summer viviparous female.—Four collections, May 6 to 26.

Alate viviparous female.—Five collections, May 4 to 28.

Types in collection of United States National Museum (Slides No. 11921); paratypes in collection of Colorado Agricultural Experiment Station.

This species is peculiar in the wide variation of color exhibited from the light green examples to the nearly black ones. This is likely to give the impression of two species in a colony.

***Myzus polemonii* n. sp**

Apterous summer viviparous female.—(Plate II, Figs. 10 and 13). Described from type taken on *Polemonium* sp. in Cherokee Park, Colorado, September 20, 1915, by L. C. Bragg.

Color: Impossible to determine, as specimen was not observed before being placed in balsam.

Measurements: Body, to base of cauda, 3 mm.; hind tibiæ, 2 mm.; antennæ, 2.90 mm.; joints as follows: III, .78 mm.; IV, .38 mm.; V, .41 mm.; VI, .12 mm. + .80 mm.; cornicles, .80 mm.; cauda, .28 mm.

Structural characters: Secondary sensoria on joint III only, 30 in number; hairs slightly capitate on body, .05 to .06 mm. long, fairly numerous; on antennæ similar but slightly shorter; on legs similar but more numerous; on cauda pointed, curved, .08 mm. long, 2 on each side and 1 on dorsal side; cornicles cylindrical, faintly imbricated at distal end; cauda bluntly conical; frontal tubercles distinct and somewhat converging; ocular tubercles present.

Alate viviparous female.—(Plate I, Fig. 5; Plate II, Figs. 11, 14 and 15). Described from type and 10 paratypes taken on *Polemonium* sp., in Cherokee Park, Colorado, September 20, 1915, by L. C. Bragg.

Color: Abdomen light green, slightly dusky on median portion; thorax and head black, with intersegmental membranes green; cauda pale greenish; antennæ and legs, except proximal one-third of femora

and tibiae, dusky brown to blackish, black on tips of joints and tarsi; cornicles pale greenish to colorless; stigmas pale honey-yellow.

Measurements: Body, to base of cauda, 2.6 mm.; hind tibiae, 2 mm.; antennae, 3 mm.; joints as follows: III, .90 mm. (.76 to .93 mm.); IV, .47 mm. (.44 to .50 mm.); V, .47 mm. (.43 to .49 mm.); VI, .13 mm. + .82 mm. (.70 to .92 mm.); cornicles, .65 mm.; cauda, .22 mm.

Structural characters: Secondary sensoria on antennae tuberculate; on joint III, 90, scattered throughout entire length of joint; on IV, 10 and 16 (10 to 20) mostly on proximal one-half of joint; none on V; hairs, cornicles, cauda, and tubercles as in apterous viviparae; fore wings with mediae twice branched; hind wings with two cross veins.

Male.—(Plate I, Fig. 6; Plate II, Fig. 12). Described from type and 2 paratypes taken on *Polemonium* sp., in Cherokee Park, Colorado, September 20, 1915; collected by L. C. Bragg.

Color: Head and thorax reddish-brown to black; abdomen reddish-brown with large areas of light honey-yellow surrounding bases of cornicles; cauda pale reddish-yellow; legs pale with tips of femora dusky and tips of tibiae and entire tarsi black; antennae dusky to black throughout; cornicles pale yellowish; stigmas dusky honey-yellow.

Measurements: Body, to base of cauda, 2 mm.; hind tibiae, 1.70 mm.; antennae, 3 mm.; joints as follows: III, .68 mm. (.68 to .73 mm.); IV, .44 mm. (.40 to .44 mm.); V, .48 mm. (.45 to .48 mm.); VI, .15 mm. + .95 mm. (.90 to 1.03 mm.); cornicles, .35 mm. (.30 to .35 mm.); cauda, .12 mm. (?).

Structural characters: Alate; secondary sensoria on antennae, tuberculate, scattered throughout entire length of joints, on III, 71 (71 to 83) in number; IV, 30 (21 to 30); V, 16 (13 to 16); other characters as in alate viviparae.

Collections were made on leaves and stems of *Polemonium foliosissimum* (?) in altitudes of about 7,000 feet on eastern slope of Rockies in northern Colorado, by L. C. Bragg and the junior author as follows:

Apterous summer viviparous female.—One collection, September 9.

Alate viviparous female.—Three collections, June 26 to September 4.

Male.—One collection, September 20.

Types in collection of the United States National Museum (Slides No. 41,920); paratypes in collection of the Colorado Agricultural Experiment Station.

This species was very abundant in the cases discovered. In all collections the alate form predominated, in fact, in the June collection a large number of alatae were found, but not a single apterous example.

Myzus polemonii n.sp. bears some resemblance to *Macrosiphum purpurascens* Oest., but differs in the larger size of the body, 3 mm., the greater length of the spur, .70 to .90 mm., and the larger number of antennal sensoria on joint III, while *purpurascens* Oest. has body length, 2mm.; spur, .40 to .54 mm., and sensoria on joint III, 19 to 26 in number.

***Amphorophora geranii*, n. sp.**

Apterous summer viviparous female.—(Plate I, Fig. 8; Plate II, Figs. 16, 18, 20 and 22). Described from type and numerous paratypes taken on *Geranium Richardsonii* in Big Thompson Canon, near Estes Park, Colorado, July 16, 1915, by L. C. Bragg; also numerous paratypes taken near Boulder, Colorado, June 30, 1912, and August 16, 1912, and one taken at Lyons, Colorado, June 11, 1916, all on above mentioned host and by L. C. Bragg.

Color: Dull green-yellow, pinkish in some paratypes, lighter anteriorly, on abdomen mottled with grass green tinged with dusky, especially on dorso-medial line to region of cornicles; cauda concolorous with body; legs pale greenish to pale brownish with tarsi and tips of tibiae dusky to blackish; antennae dusky except joints I and II and base of III; cornicles pale greenish on proximal one-third, dusky on distal two-thirds.

Measurements: Body, to base of cauda, 3.65 mm.; hind tibiae, 2.80 mm.; antennae, 3.90 mm.; joints as follows: III, .85 mm. (.71 to .93 mm.); IV, .78 mm. (.72 to .97 mm.); V, .62 mm. (.54 to .79 mm.); VI, .18 mm. + 1.02 mm. (.93 mm. to 1.20 mm.); cornicles, .95 mm. (.72 to 1.05 mm.); cauda, .43 mm.

Structural characters: Secondary sensoria on antennal joint III only, 5 and 8 (4 to 8) in number; hairs on body slightly capitate, .05 mm. long, rather sparse; on antennae similar but rather numerous; on legs similar but more numerous; on cauda pointed, curved, .09 mm. long, and 6 or 7 on a side; cornicles slightly swollen on inner side of distal half, very slightly imbricated or smooth; frontal tubercles large and diverging; lateral tubercles lacking; ocular tubercles distinct.

Alate viviparous female.—(Plate I, Fig. 7; Plate II, Figs. 17, 19 and 21). Described from type and one paratype taken on *Geranium Richardsonii*, near Lyons, Colorado, June 11, 1916, another paratype taken at Boulder, Colorado, June 30, 1912, and one other taken near Estes Park, Colorado, July 16, 1915, on same host as above and by L. C. Bragg.

Color: Thoracic lobes brownish, remainder of dorsum dull green-yellow, tinged with grass green on pronotum and mottled with sooty green on abdomen, especially on median line to region of cornicles; cauda concolorous with body; cornicles pale on proximal one-third, dusky on distal two-thirds; antennae dusky except joints I and II and base of III; legs pale brownish with tarsi and tips of tibiae black; stigmas dusky honey-yellow.

Measurements: Body, to base of cauda, 3.15 mm.; hind tibia 2.90 mm.; antennae, 4 mm.; joints as follows: III, .82 mm. (.71 to .92 mm.); IV, .85 mm. (.73 to .92 mm.); V, .72 mm. (.55 to .78 mm.); VI, .21 mm. + 1.10 mm. (1.05 to 1.35 mm.); cornicles, .85 mm. (.70 to .95 mm.); cauda, .35 mm.

Structural characters: Secondary sensoria on antennal joint III only, 17 (14 to 26) in number; hairs, cornicles and tubercles as in apterous summer viviparae; fore wings with mediae twice branched; hind wings with two cross veins.

Collections were taken on *Geranium Richardsonii* in foothills of eastern slope of the Rockies, mostly in northern Colorado, by L. C. Bragg and the authors, as follows:

Apterous summer viviparous female.—Twelve collections, June 7 to August 22.

Alate viviparous female.—Seven collections, June 7 to July 16.

Types in United States National Museum (Slides No. 41,922); paratypes in collection of Colorado Agricultural Experiment Station.

This species resembles *Amphorophora cicutæ* Shinji on *Cicuta virosa* var. *californica*. It differs in proportions between antennal joints III and IV which are subequal in *A. geranii* while they are as 110 to 90 in *A. cicutæ*. The sensoria are apparently more numerous on antennæ in *A. geranii*, though some individuals did not show more. The difference of host also makes it more advisable to consider the two species distinct until more extensive study and biological tests can be carried out.

***Rhopalosiphum bossekiae*, n. sp.**

Apterous summer viviparous female.—(Plate I, Fig. 9; Plate II, Figs. 23, 24 and 25). Described from type and 7 paratypes taken on *Bossekia (Rubus) deliciosæ* at Boulder, Colorado, July 1, 1912, by L. C. Bragg, also 14 paratypes taken June 11, 1909, and 1 taken June 30, 1915, on same host at Fort Collins, Colorado, by the senior author, also numerous others taken on same host, at Boulder, Colorado, August 11, 1912, and at Fort Collins, Colorado, June 13, 1918, by L. C. Bragg, and July 26, 1911, by the junior author.

Color: Light greenish-yellow, with green longitudinal streak on median line in region of cornicles; cauda and cornicles concolorous with body; antennæ somewhat dusky, except first three joints, which are pale yellowish; legs pale except tarsi and tips of tibiae which are dusky to blackish; eyes dark red or black; red eyes of embryos are visible through dorsum of abdomen; surface of body rugose or reticulated.

Measurements: Body, to base of cauda, 1.80 mm. in length; hind tibiae, 1.00 mm. (.60 to 1.10 mm.); antennæ, 1.30 mm. (.90 to 1.30 mm.); joints as follows: III, .34 mm. (.20 to .42 mm.); IV, .24 mm. (.13 to .31 mm.); V, .20 mm. (.14 to .26 mm.); VI, .10 mm. + .46 mm. (.30 to .55 mm.); cornicles, .47 mm. (.36 to .55 mm.); cauda, .11 mm.

Structural characters: Secondary sensoria present on antennal joint III, 2 (0 to 3) in number; hairs on body blunt or capitate, .03 to .04 mm. in length, and fairly numerous; on antennæ blunt, .01 mm. long and sparse; on legs similar to those on body; on cauda pointed, curved, .05 to .06 mm. long, and 3 or 4 on a side; cornicles somewhat swollen on inner side on distal one-third and slightly curved at base, neither reticulated nor imbricated, but somewhat transversely wrinkled or rugose on proximal one-third; cauda nearly parallel sided, rounded

at tip and without evident constriction; frontal tubercles not distinct; lateral tubercles inconspicuous, found on abdominal segments 2, 3 and 4; ocular tubercles present.

Alate viviparous female.—(Plate I, Fig. 10; Plate II, Fig. 26). Described from type taken on *Bossekia deliciosa*, at Boulder, Colorado, July 1, 1912, by L. C. Bragg, 5 paratypes taken on the same host, at Fort Collins, Colorado, June 11, 1909, and June 30, 1915, by the senior author, and 2 other paratypes taken June 13, 1918, by L. C. Bragg, on same host and locality.

Color: Abdomen and pronotum pale green mottled with darker on dorsum of abdomen; head and thorax yellowish-brown; antennæ slightly dusky except first two joints and base of third; cauda, cornicles and legs pale brownish-yellow, except tips of tibiæ and entire tarsi which are black or blackish.

Measurements: Body, to base of cauda, 1.80 mm.; hind tibiæ, 1.15 mm.; antennæ, 1.75 mm.; joints as follows: III, .43 mm. (.28 to .48 mm.); IV, .28 mm. (.25 to .33 mm.) V, .23 mm. (.20 to .32 mm.); VI, .11 mm. + .55 mm. (.55 to .65 mm.); cornicles, .45 mm. (.40 to .52 mm.); cauda, .19 mm.

Structural characters: Secondary sensoria on antennal joint III only, 10 (5 to 12) in number; hairs, cornicles, cauda, and tubercles as in apteræ; fore wings with mediæ twice branched; hind wings with two cross veins.

Collections were taken on *Bossekia deliciosa* in foothills of eastern slope of northern Colorado, by L. C. Bragg and the authors as follows:

Apterous summer viviparous female.—Seven collections, June 13 to August 30.

Alate viviparous female.—Two collections, June 30 and July 1.

Types in collection of the United States National Museum (Slides No. 41923); paratypes in collection of Colorado Agricultural Experiment Station.

This species resembles *Aphis rubicola* Oest. in the number of antennal sensoria and wrinkled appearance of the cornicles but measurements of both antennæ and cornicles differ greatly and the shape of the cornicles clearly shows the two to belong to different genera.

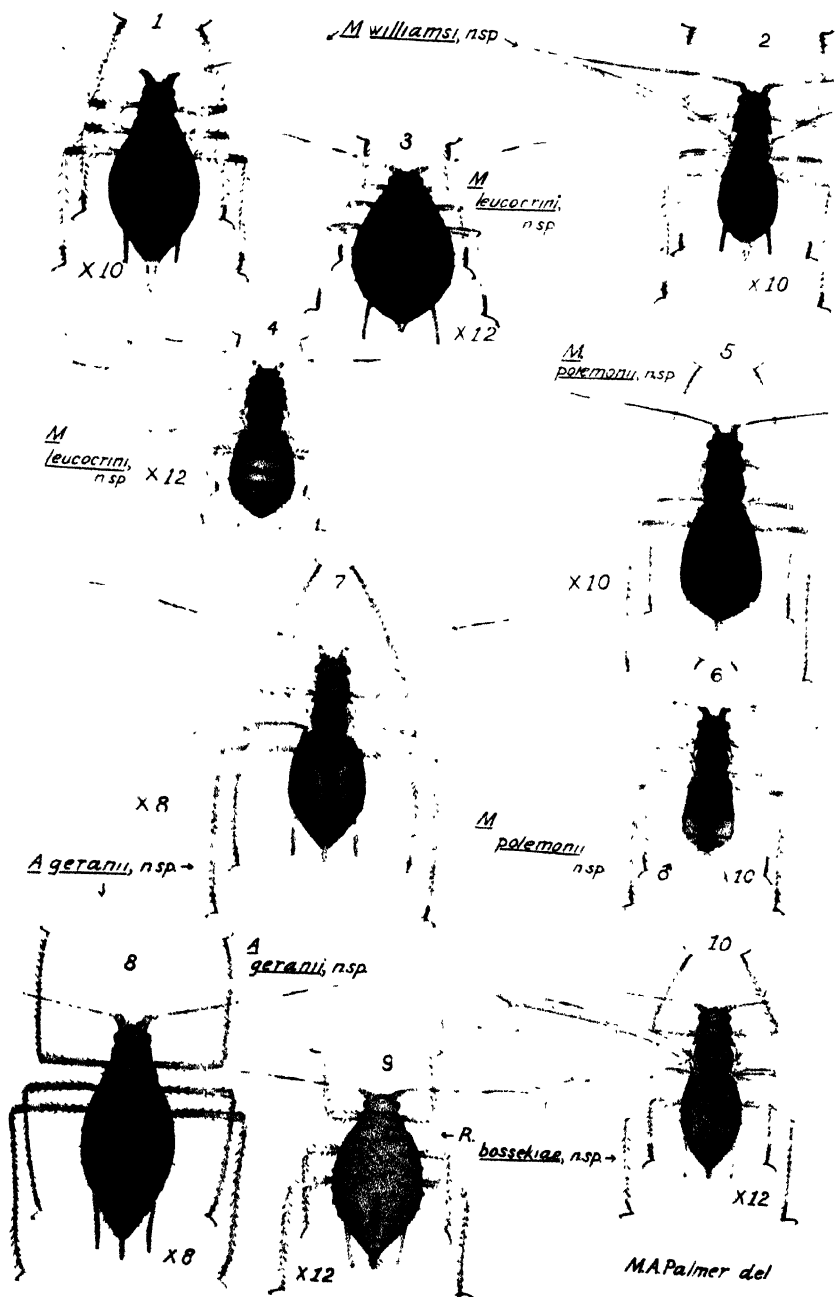
EXPLANATION OF PLATES.

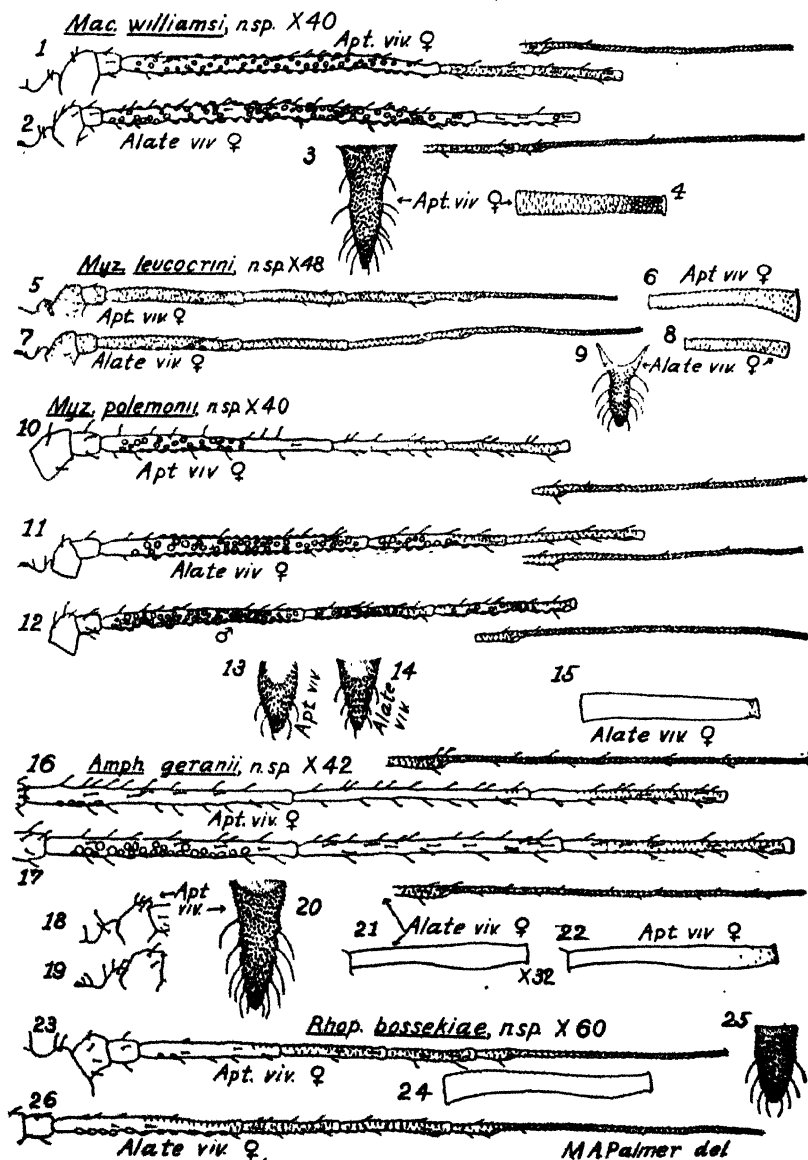
PLATE I.

- Macrosiphum williamsi*, n. sp. 1, apterous summer viviparous ♀; 2, alate viviparous ♀.
Myzus leucocrini, n. sp. 3, apterous summer viviparous ♀; 4, alate viviparous ♀.
Myzus polemonii, n. sp. 5, alate viviparous ♀; 6, ♂.
Amphorophora geranii, n. sp. 7, alate viviparous ♀; 8, apterous summer viviparous ♀.
Rhopalosiphum bossekia, n. sp. 9, apterous summer viviparous ♀; 10, alate viviparous ♀.

PLATE II.

- Macrosiphum williamsi*, n. sp. 1, antenna of apterous summer viviparous ♀; 2, antenna of alate viviparous ♀; 3, cauda, and 4, cornicle of apterous summer viviparous ♀.
Myzus leucocrini, n. sp. 5, antenna, and 6, cornicle of apterous summer viviparous ♀; 7, antenna, 8, cornicle, and 9, cauda of alate viviparous ♀.
Myzus polemonii, n. sp. 10, antenna of apterous summer viviparous ♀; 11, antenna of alate viviparous ♀; 12, antenna of ♂; 13, cauda of apterous summer viviparous ♀; 14, cauda, and 15, cornicle of alate viviparous ♀.
Amphorophora geranii, n. sp. 16, antenna of apterous summer viviparous ♀; 17, antenna of alate viviparous ♀; 18, vertex of apterous summer viviparous ♀; 19, vertex of alate viviparous ♀; 20, cauda of apterous summer viviparous ♀; 21, cornicle of alate viviparous ♀; 22, cornicle of apterous summer viviparous ♀.
Rhopalosiphum bossekia, n. sp. 23, antenna, 24, cornicle, and 25, cauda of apterous summer viviparous ♀; 26, antenna of alate viviparous ♀.





NOTES ON THE IMMATURE STAGES AND BIOLOGY OF A BIRCH CASE-BEARER.*

K. A. SALMAN,
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During the summer of 1927 case-bearing larvæ were found causing serious injury to white and gray birches near Newport Mountain, in the town of Bar Harbor, Mount Desert Island, Maine. The infestation was not considered important, as it occurred on an area that had suffered recently from fire and on trees that were in a somewhat weakened condition. During the summer of 1928, however, the insect was found in other parts of Bar Harbor attacking healthy trees and causing almost complete destruction of the leaves of those trees so that it can be said to be an important pest of birch trees in the infested area. The insect does not appear to be widespread in its distribution for, with the exception of the relatively heavy infestation on Mount Desert Island, most of which is within the limits of the town of Bar Harbor, there are but two towns on the mainland (Trenton and Ellsworth) in which the insect has been found. The limited area of the infestation on the island and the spread of the insect along the main road of travel from the island to the mainland and on the mainland would lead one to assume that the insect concerned was either a relatively recent introduction from some foreign country or a species occurring in some other part of this country and but recently transported to Mount Desert Island. This was not found to be the case, however, for specimens of the adult which were sent to Mr. Carl Heinrich, of the United States National Museum, were determined by him as belonging to a new species (*Coleophora salmani* Heinrich) the description of which appeared in the Proceedings of the Entomological Society of Washington, Vol. 31: 18, 1929.

*The material presented in this paper is the result of investigations conducted for the Maine Forest Service under the direction of Mr. H. B. Peirson.

NOTES ON THE IMMATURE STAGES.

Egg.—Length 0.35 to 0.44 mm.; width 0.24 to 0.28. The egg is usually oval although its shape may be modified somewhat by the presence of other eggs touching it or by the hairs of the leaf to which it is attached. The surface of the egg is finely pitted, the micropylar portion having a number of rounded projections which give it a "pebbled" appearance. It is yellow or orange in color when first laid, but, as the embryo develops, becomes light yellow and a dark area appears at the micropylar end due to the color of the head capsule of the developing larva which shows through the shell.

Larva.—Four distinct instars have been observed, but calculations made according to Dyar's Law (*Psyche* 5: 420-422, 1890) from measurements of the head capsules indicate that there are five larval instars, the first, second, third and fifth of which have been observed and collected. The shape of the larva is cruciform. The thoracic segments are somewhat wider than the other body segments and the dorsum of the terminal abdominal segment, in the later instars at least, is sclerotized heavily, possibly to act as a protection against injury for the distal portion of the case borne by the larva is open. The thoracic legs are well developed. The anal prolegs are the only ones which are distinct and each of these bears a single transverse row of crochets. The later larval stages show a slight development of prolegs on the 3rd, 4th and 5th abdominal segments and each of the prolegs bears a variable number of crochets.

1st Instar.—Length 1.17 mm.; width of head capsule 0.14 mm. Head capsule, thoracic legs and dorsum of the 1st thoracic segment sclerotized. Body cream-colored or greenish.

2nd Instar.—Average length 1.55 mm.; width of head capsule 0.19 mm. Head capsule, thoracic legs and dorsum of 1st and 2nd thoracic segments and of anal segment of abdomen sclerotized. Body greenish in color.

3rd Instar.—Width of head capsule 0.27 mm. Body very similar in appearance to larva of the 2nd instar except that it is darker in color, and, during the period of hibernation, is contracted.

4th Instar.—Larvæ of this stage have not been observed, but calculations show there to be one instar having a head width of approximately 0.34 mm.

5th Instar.—Width of head capsule 0.49 mm. (Calculated as approximately 0.46 mm.*). Body shape and color similar to 2nd instar but somewhat larger and darker.

*The specimens from which the measurements were made had been pressed and dried in their cases. Although the specimens showed but very slight distortion of the head capsule, it is possible that the difference between the observed and the calculated widths is due to the flattening of the head capsule in the process of pressing the cases.

LARVAL CASES.

The larvæ of the 1st instar do not form cases, but mine in the leaves. There have been four different types of cases found and the larvæ of the 2nd to 5th instars (inc.), as well as the pupal stage occur in one or another of these types. These types of cases are similar in shape to those of the Cigar Case-bearer (*Coleophora fletcherella* Fernald).

Type 1.—This type of case is formed entirely of the epidermal layers of the mined area of the leaf. It is of variable size, but on the average is about 2.5 mm. long from tip to tip. It consists of a curved tubular portion, open at both ends, one of which is attached to the leaf, the other serving as an opening through which the larval excreta is voided. There are two fin-like longitudinal ridges formed by the cut edges of the epidermal layers, one dorsal and one ventral. The dorsal one, which is on the convex side of the tubular portion, is narrow and soon wears (?) away. The ventral "fin" is more persistent, remaining on the case and forming a lamina which fills the space on the concave or ventral side formed by the curving of the tubular portion. Larvæ of the 2nd instar only have been found inhabiting this type of case.

Type 2.—This type of case is of about the same size as the preceding and is made of the same material. It differs in that the distal portion of the central tube is flattened and nearly closed and that the fin-like margins of the ventral and dorsal sides of the case are continued over the distal portion of the case. This case may be formed from a case of type 1, but the flattening of the distal end and the presence of the ridge extending over this portion would indicate that this is the second case to be formed by a larva. Larvæ of the 3rd instar inhabit this type of case.

Type 3.—This case differs from the preceding in shape and in the material used for its construction. It is somewhat larger, being from 3 to 3.5 mm. from tip to tip and the curve of the tubular portion in which the larva remains is much more abrupt than in the preceding types. The distal portion only is composed of the epidermal layers of a leaf. The basal portion, usually nearly half the entire case, is composed of a granular material of indeterminate origin which has been placed in layers around the mouth of the portion formed from the epidermal layers. The granular material forming the layers is held together by silken threads. The distal portion of the case is somewhat flattened, although not as much as in a type 2 case. Only one larva has been found in a case that was distinctly of this type, but it is known that the 3rd and 4th larval instars occur at the time when these cases are to be found. This type is evidently a type 2 case to which the granular material has been added at the base. Several cases containing hibernating larvæ of the 3rd instar have been found that had a small amount of granular material at the base, but the extreme development of this type of case does not usually occur until late spring or early summer.

Type 4.—An elongate, cigar-shaped case which is usually over 5 mm. in length and which has a width of from 1.5 to 2 mm. at its widest portion. It is formed entirely of epidermal layers of a leaf. When first formed it has relatively wide dorsal and ventral "fins" running the full length of the case, but these disappear after a few days and the case becomes nearly cylindrical. The basal opening is cut at an angle of about 45° so that, when it is attached to a leaf the case is not vertical to the leaf surface but slopes at about this angle. The apex of the case is open, but its edges are pinched together so that the larva contained therein is partially protected. Larvæ of the last or 5th instar and pupæ are to be found in cases of this type.

Pupa—Length 3.3 mm. to 4.7 mm.; width 1 mm. It varies in color from a light to a dark brown, according to the age of the pupa. The tip of the abdomen is blunt and rounded and a protuberance bearing two short, conical spines at its apex projects from each side of the abdomen near the tip. The pupa is formed in a type 4 case

BIOLOGY.

General.—There is but one generation a year of this insect in the locality in which these studies were made. The eggs are laid about the middle of July and hatch during the first week of August. The larvæ feed for a time between the epidermal layers of the leaf and form their cases from the layers of the area mined. They hibernate in their cases on the twigs of the host plant and begin their feeding activities again in the spring, becoming full grown about the last of June or first of July and pupating at that time.

Adult habits.—The adults are not very active in intense sunlight and usually remain hidden on the undersides of leaves, on stems, or in any partially shaded place affording shelter during the daytime. They rise up in numbers when the foliage is disturbed but soon alight and hide again. On cold or rainy days they also remain in protected places. They rest on the leaf surface with the anterior portion of the body raised from the leaf and with the tip of the abdomen touching the leaf surface. The grayish antennæ are held together straight out in front of the body and the wings are folded so that the outline of the insect is triangular, the antennæ projecting from the head or apex of the triangle as a single thread-like process. The habit of hiding, which is noticeable in the adult, would seem to indicate that the insect is negatively phototropic during this stage. Adults liberated in the laboratory, however, always flew to a window, but those which emerged in boxes into one

side of which a bottle had been inserted were not attracted to the light entering through the bottle and remained motionless inside the box.

The first adults to be reared in the laboratory in 1927 emerged from field collected material on July 14, but, as eggs were found in the field at that time, emergence under natural conditions must start somewhat earlier. In 1928 the first adult was found in the field on July 6 although the greater number of adults did not emerge from the field collected material held in the laboratory until after July 10. Few adults were to be found in the field after the first week of August.

The individuals mate a few hours after emergence and a pair has been noted as remaining in the copulatory position from 9:30 a. m. until 4:30 p. m., a period of seven hours. Other pairs noted separated after a shorter period. When mating, the two individuals remain nearly motionless, the tips of their abdomens joined and the insects facing in opposite directions. In one lantern globe cage which was attached to a twig of a white birch tree in the field an example of the attraction of males by females was observed. The cage contained three living females and two males, one of which was mating with a female at the time of observation. Outside the cage, however, six males were found to have crawled up under the cheese cloth covering of the top of the lantern globe in an attempt to gain access to the females. Four of these males were living and were endeavoring to pass the restricting rubber band which held the cheese cloth in position while two had died in attempting to gain access to the interior of the cage.

In the glass cages on trees in the field two females laid 9 eggs each, one 10 eggs and one 21 eggs in one day of twenty-four hours. In the laboratory one female is recorded as laying 20 eggs on the first day, 8 between 8:30 a. m. and 5:00 p. m. of the second day, 2 between 5:00 p. m. and 8:30 a. m. of the following morning, 3 the third day, 2 the fourth day and 4 in the three days following or a total of 39 eggs laid over a period of seven days. Other records of females which were reared and mated in the laboratory show that the greater number of eggs are laid during the first day after mating and that seven days is about the average length of time during which eggs are laid. The length of life of adult females has been recorded as being from 7 to 10 days., from emergence from the pupa to death. Males usually live from 6 to 8 days.

Egg.—Eggs are found in the field only on the under surfaces of leaves although a few eggs were laid on buds or on the upper surfaces of leaves under the unnatural conditions imposed on the female by the lantern globe cages. Eggs have been found deposited under field conditions on *Betula alba*, *Corylus americana* and *Alnus sp.* and, although the white birch seems to be the favorite host, many eggs are laid on the other two host plants. Gray birch is subject to extensive injury by the larvæ of the case-bearer, but, in spite of careful search, no eggs have been found laid on the leaves of this species. This may be due to the lack of heavy pubescence on the under surface of the gray birch leaf for the plants on which eggs have been found all have the under surface of the leaf densely pubescent and the eggs are usually found among and attached to the hairs of the leaf. The eggs are usually laid among the hairs at the junctions of the midrib with the main lateral veins. They may be laid beside the midrib and some have been found beside the lateral veins. Few eggs have been found on the lower leaf surface away from the protection afforded by the larger veins. They may be laid singly or in groups and when laid in groups, no definite order of placement is observed.

As many as 33 eggs have been found in the field on the under surface of a single leaf. All the leaves of several branches of trees occurring in the heavily infested locality in which this insect was first found were examined and it was found that there was an average of 6.2 eggs per leaf. Similar counts were made of the leaves on branches which were shaded, branches exposed to the sunlight and branches in partial shade. There was an average of 10.5 eggs per leaf on shaded branches, 3.5 eggs per leaf on branches exposed to sunlight and 4.6 eggs per leaf on branches in partial shade. This indicates that the amount of exposure of the leaves of a tree to sunlight may have some effect on the number of eggs laid on them.

I have but a few records of the length of the egg stage and these are accurate only to within two or three days. Those which have been taken, however, indicate an egg stage of about three weeks. Eggs have been recorded as occurring in the field from the second week in July until the first week in August.

Larval Habits.—The eggs of the birch case-bearer hatch about the first week in August. The larvæ emerging from these

eggs bite their way through the distal "pebbled" portion of the shell and wander over the lower surface of the leaf for a short time. They soon select a place, bite their way through the epidermis and begin to mine through the inner tissues of the leaf. One larva which was observed entering the leaf did not eat any of the epidermal tissue, but placed the particles beside the opening of the mine. When inside the leaf it fed normally on the tissues. It cannot, however, be definitely stated that the habit of rejecting the epidermal tissues is typical. It takes about two hours for a larva to completely bury its body in the leaf tissues.

Larvæ have been observed in their mines in the leaf as late as August 26. All but a very few of the larvæ collected from mines were of the 1st instar, but it is possible that they molt once in the mine and then cut their cases from the epidermal layers. This is suggested by the fact that a few larvæ of the 2nd instar have been taken from mines.

Cases of type 1 have been found in small numbers as early as August 24th, the number of cases of this type being found in the field increasing rapidly after that date. Cases of type 1 have not been found to contain larvæ of any but the 2nd instar. This instar is evidently completed by the second or third week in September for collections made by Mr. H. B. Peirson on September 16 revealed but two type 1 cases.

Type 2 cases are abundant during the latter part of September and in October and all the cases examined have been found to contain larvæ of the 3rd instar. It is in the 3rd instar and in a type 2 case that the case-bearer hibernates. From the time of the cutting of the first cases from the leaves until the migration which preceeds hibernation the larvæ of the 2nd and 3rd instars have been feeding in the usual manner of Coleophorids. The larva moves its case from one part of the leaf to another and fastens it down with silken threads, mines through the leaf by crawling part way out of the case and, when it has eaten all the tissue it can in this manner, unfastens the case, crawls with it to another part of the leaf and repeats the process. When ready to hibernate it migrates to a twig and attaches the case. The host plants attacked by these late summer and fall instars are the same as those on which the eggs were laid.

Feeding is resumed in the spring and the mines made by the feeding larvæ at this time are much larger than those made in the fall. Larvæ of the 4th instar have not been collected or measured, but the type 3 cases occur during the spring and early summer and the 4th instar larvæ must occur at this time so that it is permissible to speculate that the larvæ of this instar do much of the feeding done at this time of year. It is not known when the majority of the larvæ molt and enter the final or 5th instar. Cigar-shaped cases containing full grown and feeding larvæ have been recorded in the field as early as July 2 and one individual has been noted as having left its type 3 case on July 9 and as forming its type 4 case on July 10. Usually, however, most of the larvæ have formed their cigar-shaped case before this time and have already pupated.

In addition to the host plants attacked by the early fall instars there are three others upon which the larvæ of the later instars have been found feeding to some extent, although, to my mind, the occurrence and feeding on two of these plants was purely accidental. The plants concerned are *Salix sp.*, *Quercus rubra*, and *Betula populifolia*, the last-named evidently being a preferred host, although as noted above no eggs have been found on plants of this species.

Pupa.—The case-bearer usually migrates to nearby twigs when ready to pupate, although many pupate on the leaves. It is probable that, during the migration, many drop from the trees on which they have been feeding to the plants beneath for trunks, leaves and needles of a great number of species of plants found beneath the infested trees had many pupal cases on them although no feeding injury was observed. The larva, on reaching the place at which it is to pupate, firmly fixes the base of the case to the object, sometimes merely by attaching it with silken threads, at other times, as was observed on white pine needles, by excavating a hole in the needle and firmly attaching the edge of the case to the rim of the excavation. Then it spins a silken plug to close the hole at the base of the case and turns around so that its head is facing towards the distal end. It molts again and enters the pupal period, the molted skin being pushed down on the silken plug. Full grown larvæ enter the pupal stage over a period of several weeks and the majority of larvæ have pupated by the first week in July. Although early adults appear before some late larvæ

have pupated the greater number of individuals do not emerge until the second week in July. The pupal stage has been recorded as lasting 14 or 15 days.

Natural control.—This species does not seem to be attacked by many predators or parasites although a few have been collected or reared. The mortality of hibernating larvæ must be very high, however, for many dead larvæ have been found in their cases on the twigs and leaves.

Trombidium sp.—Nymphal stages of a mite, the identity of which was kindly determined by Dr. Nathan Banks, were found on the leaves of birch feeding on eggs of the case-bearer. The mites suck the contents from the eggs and were particularly abundant in the glass cages on the trees. In one cage 62 out of 66 eggs had been sucked and in another 29 out of 57 eggs had been destroyed. One mite was observed eating a dead case-bearer moth. Outside the cages the eggs of the case-bearer were attacked to some extent, but the activities of the mites were not very noticeable.

Several individuals of Ichneumonoid Hymenoptera were reared from the pupæ of the case-bearer. Dr. C. F. W. Muesebeck kindly determined them as of the following species: *Hemiteles tenellus* (Say), *Itoplectis conquisitor* (Say) and *Orgilus sp.* and stated that the first and second-named "are very common species, the former usually, and the latter very frequently acting as hyperparasites." The exact relations of these with the case-bearer were not determined and it is very probable that they may constitute a portion of a hyperparasitic group of species. The status of *Orgilus sp.* was not determined.

A HANDBOOK OF THE DRAGONFLIES OF NORTH AMERICA.

By J. G. NEEDHAM and HORTENSE BUTLER HEYWOOD. Charles C. Thomas, Publisher, Springfield, Ill. and Baltimore, Md. pp. I-VIII-378.

Primarily intended for collectors and students of systematic entomology this book includes much information relating to the habits and life-histories of this interesting group of insects. The first forty-six pages are devoted to a general discussion of the group, the structures used in classification and the general habits with directions for collecting and preserving. The remainder includes keys and descriptions for the identification of the North American species.

H. O.

NEW SYRPHIDÆ AND TACHINIDÆ.

C. H. CURRAN.

American Museum of Natural History.

Descriptions of new species of flies from various parts of the world are given herewith. Rather than present separate papers each dealing with a different faunal region, the descriptions are presented in the one paper. Disposition of the types is indicated following each species.

SYRPHIDÆ.

The species described below was collected by Dr. E. Escomel in the arid region of Peru and was forwarded, along with some other Diptera from the same source, by Dr. T. D. A. Cockerell, to whom I am greatly indebted for the privilege of retaining the specimens.

Volucella escomeli, new species.

In my key, (Ann. Ent. Soc. Amer., xix, p. 51, 1926) traces to couplet 30 where it fits neither alternative since the scutellum bears six or seven pairs of strong setigerous tubercles and the abdomen is mostly pale luteous yellow. If carried to couplet 32 it agrees fairly well with *concinna* Philippi but there is a slight facial tubercle and the frontal triangle is not nearly as wide transversely and is more acute above. Length, 12 to 16 mm.

Male.—Head sub-translucent yellowish, the very small vertical triangle reddish. Face perpendicular, broad, widening below, slightly produced at the upper two-fifths, thence perpendicular to the lowest fourth where it recedes, the lowest part again perpendicular, the oral angles acute; oral margin evenly oblique in profile, the cone sharp. Pile black on the front, the sides and middle of the face and on the vertical triangle, elsewhere fine and pale yellowish, on the eyes grayish white; no long occipital pile. Antennæ reddish; third segment regular, slightly tapering; arista mostly brown, with long black rays above and below; the antennæ not one-third as long as the face.

Thorax greenish black, the broad sides of the mesonotum and most of the mesopleura luteous; pile abundant, very fine, crinkly, grayish white, the mesonotum and upper part of the pleura with coarser black hairs intermixed. Scutellum large, translucent luteous, with short black hair on the disc, the border with fine, pale pile; the apical tubercles are strong, the basal pair obsolete or nearly so; a deep concavity between the apical pair of tubercles. Four to six strong pre-scutellar bristles.

Femora and tarsi black, the apices of the former and the basal two or three segments of the posterior tarsi except their apices, reddish, the tibiae reddish yellow. Hair black.

Wings hyaline; stigma small, blackish; small crossvein narrowly blackish; marginal cell slightly widened, the petiole long, apical.

Abdomen translucent luteous, the first three segments with a narrow black vitta which is interrupted at the second incisure and continues as an oval spot onto the fourth segment, the sides of the third and fourth segments with large blackish triangles posteriorly, the second with very small ones, those on the third extending obscurely along the posterior border, the fourth segment with brownish stain except on the broad base and apex. Pile very short, coarse, black, the broad bases of the apical three segments clothed with fine whitish pile. Venter pale yellow; third sternite with a small transverse black spot apically, the fourth black on the median half, the pile black only on the black part of this sternite.

Female.—Front moderately wide, the lateral depressions large, sharply defined, wider than the gentle median convexity; front widening anteriorly, wholly black haired. Antennae slightly larger than in male. Fifth abdominal segment small, brown with the middle broadly yellow.

Type male and allotype female, Arequipa, Peru, (Dr. E. Escomel) in Curran collection. Paratypes: 2♂ 5♀, Yura, Peru, (T. D. A. Cockerell), in American Museum of Natural History.

Volucella concinna Philippi, with which this species is likely to be confused, has black triangles on all the sternites.

***Baccha bromleyi* n. sp.**

Blackish, the wings lightly brownish, hyaline basally; sides of abdomen parallel. Length, 11 mm.

Male.—Face, front and cheeks, reddish yellow, the cheeks somewhat brown in front. Occiput black, thickly grey pollinose, whitish pilose below, yellowish above; vertical triangle black, thinly brown pollinose, black pilose, the pile of the front and face black. Front as long as the face, very gently convex, more prominent anteriorly, where there is an oval, shining black central spot, the sides narrowly whitish pollinose; eyes touching for a distance about equal to the length of the vertical triangle. Face receding, with a large, moderately prominent tubercle, the sides of the face whitish pollinose. Antennae dark reddish, the third segment brown on apical half, decidedly wider than long, the apex obtusely rounded; arista brown except basally.

Mesonotum and scutellum aeneous, pale pilose, the broad lateral margin in front of the suture, the posterior calli and the base of the scutellum rather obscurely yellow; scutellum black haired. Pleura blue-black, the posterior half of the mesopleura and a rectangular, contiguous spot on the sternopleura, yellow. Pile yellowish.

Legs reddish yellow, the posterior femora with a very broad, preapical brown band, their tibiæ reddish brown on the apical two-thirds; posterior tarsi brownish above. Pile black except basally on the femora.

Squamæ whitish yellow, with yellow border and fringe; halteres yellow. Third wing-vein straight. Allula large.

First abdominal segment aeneous, the sides broadly yellow; abdomen bronze-black, sub-opaque except apically; second segment at the middle with a large, inwardly rounded reddish spot on either side, the spots reaching the lateral margin in their full width; third segment with similarly colored spots which are more elongate, more oblique and slightly concave in front and situated wholly before the middle of the segment; fourth segment with spots as on the third but they are longer than wide, more oblique and concave in front and reach forward to the basal sixth of the segment. Pile black and rather abundant, partly yellow on the sides of the first segment.

Holotype, male, Santiago, Las Vegas, Cuba, April 10, 1926, (S. W. Bromley), in Curran Collection.

***Baccha carlota* n. sp.**

A large species, mostly blackish, with yellow vittate thorax, the costal border reddish and brown. Length, 14 mm.

Female.—Face and cheeks pale yellow, the former with a broad, median ferruginous vitta which does not quite reach the antennal base; front ferruginous, the upper fourth dull black, the sides broadly yellow, a yellow spot above each antenna. Hair of occiput and lower half of face, yellow, elsewhere black. Antennæ rusty reddish. Face slightly receding below, the tubercle large, rounded.

Mesonotum ferruginous, with a pair of broad, widely separated reddish yellow or orange vittæ which curve slightly outwards and taper posteriorly from a little behind the suture, on the sub-posterior fifth with a narrow, median vitta of similar color; a broad yellow lateral vitta, broadly interrupted between the suture and the base of the wings. Pleura with a broad yellow fascia extending from the upper margin immediately before the base of the wings to the middle of the sternopleura, the prothorax wholly and a large spot on the hypopleura, yellow. Pile of dorsum, brown, of the sides and anterior border, yellow. Disc of scutellum brown, the border yellow, hair wholly black.

Legs yellow or reddish yellow, the hair yellow; posterior four coxæ brownish, posterior femora black except the apical sixth, the posterior tibiæ ferruginous on the apical three fifths; the black portions of the hind legs bear longer, abundant black hair and the upper surface of the posterior basi-tarsus is black haired.

Wings reddish luteous in front of the third vein, becoming brown apically; third vein rather strongly curved forwards from a little beyond the middle of the apical cell; apical crossvein bisinuate; discal crossvein oblique except on the posterior sixth. Squamæ whitish, the border and moderately long fringe, yellowish; halteres yellow.

First abdominal segment yellow, with the broad posterior border ferruginous, the pile long and whitish. Second segment reddish ferruginous, the basal fifth, broadly interrupted in the middle, yellow; third and following segments ferruginous, the basal third of the third segment yellow, the sides of the abdomen with a more reddish tinge. The abdomen is strongly spatulate, narrowest at the basal fourth of the second segment, gradually widening to the apex of the third, the fourth fully as wide as the thorax. Hair black.

Holotype, female, Mina Carlota, Trinidad Mountain, Cuba, March 24, 1925 (G. Salt), in Curran Collection.

Key to the Philippine Species of Baccha.

- | | |
|---|------------------------------|
| 1. Wings not mostly brown. | 2. |
| Wings almost wholly blackish brown. | <i>purpuricollis</i> Walker. |
| 2. Scutellum unicolorous or nearly so, at least not black with a yellow apical border. | 3. |
| Scutellum black with a yellow apical border. | <i>cochleariformis</i> Sack. |
| 3. Abdomen with yellow spots or bands or only the fourth segment black. | 4. |
| Abdomen yellowish on the basal half, the apical half black. | <i>loriae</i> Meijere. |
| 4. Scutellum partly or wholly black or brownish. | 5. |
| Scutellum entirely yellow; fourth abdominal segment wholly black. | <i>macgregori</i> n. sp. |
| 5. Scutellum wholly black or with a black or brown discal spot. | 6. |
| Scutellum yellow on basal half, black on apical half. | <i>signata</i> Sack. |
| 6. Scutellum wholly black. | 7. |
| Scutellum brown on the disc, with an entire yellow border. | 8. |
| 7. Abdomen with yellow bands. | <i>austeni</i> Meijere. |
| Abdomen with paired yellow spots. | <i>pulchrisfrons</i> Austen. |
| 8. Third antennal segment scarcely longer than wide; third longitudinal vein gently arched on its pre-apical section. | <i>meijerei</i> Kertész. |
| Third antennal segment one and one-half times as long as wide; third vein practically straight. | <i>amphithoe</i> Walker. |

Baccha macgregori, new species.

Head yellow; thorax black; scutellum wholly yellow; abdomen reddish or reddish yellow, the fourth segment wholly black, the other segments with pale brownish suffusions. Length, 11.5 to 12 mm.

Male.—Frontal triangle, face and cheeks, yellow, without pollen and with very short, pale yellowish pile; occiput black, grey pollinose, pale yellow pilose. Vertical triangle shining black, very long and narrow, the ocelli situated at its anterior extremity, the row of hair yellow. Antennæ pale orange, the third segment slightly longer than wide; arista brown.

Thorax black; pleura thinly cinereous pollinose; pile yellow, on the dorsum appressed and rather golden, broad sides of the mesonotum in front, a spot above the anterior coxæ, a large spot on the sternopleura above, most of the mesopleura, upper half of the hypopleura and the scutellum, sulphur-yellow. Scutellum without ventral fringe, the sparse hair yellow. Humeri wholly bare.

Legs yellow, the posterior basitarsi brown; posterior femora and tibiae sometimes extensively pale brownish. Hair very short, yellowish, black on the posterior femora.

Wings cinereous hyaline; subcostal cell pale brown; stigma dark brown, a rather narrow brown band extends along the costa from the stigma to the apex of the third vein. Apical crossvein very strongly curved outwards at the basal fourth, the discal crossvein less strongly so. Alula wanting. Squamæ and halteres yellowish, the squamæ without trace of fringe.

Abdomen reddish yellow; fourth segment wholly, basal half of the fifth and the extreme apex of the third, black, the second and third segments usually with a broad, somewhat darker band on the basal half, but its position variable. Genitalia yellowish. Pile sparse, short, black, yellow and longer on the first segment, sides of the second and on the genitalia.

Female.—Front very narrow, yellow in front of the ocelli; yellow haired; genitalia yellowish.

The abdomen of this species is long and slender, widening from the middle of the third segment, the second segment about as long as all the following segments combined.

Described from 2♂ + ♀, Manila, Philippines, (R. C. McGregor). Type and allotype in the United States National Museum.

***Salpingogaster punctifrons*, new species**

Allied to *pygophora* Schiner but the fourth sternite is thickly beset with black spinules and the apical projections of this sternite are more widely separated, more tapering and stouter; the spot above the antennæ is smaller, the face more retreating; the frontal triangle not with a low distinct convexity above, but almost evenly produced to the apex of the antennal prominence. Length, 15 mm.

Male.—Face reddish yellow, the middle line broadly ferruginous tinged, strongly retreating, the large rounded tubercle mostly below the middle of the face, decidedly less prominent than the antennal base. Frontal triangle ferruginous, its margin reddish yellow; a small, longitudinal ferruginous brown spot above the antennæ; frontal triangle oblique, scarcely concave on upper third, its apex convex. Vertical triangle as long as the contiguous portion of the eyes, narrow, over three times as long as broad, the ocelli situated on its front half, the anterior one remote. Occiput and vertical triangle blackish, the former, except along the orbits above, greyish pollinose. Pile of head fine, whitish, the ciliae on the whole occipital orbits with a yellowish tinge. Antennæ yellowish red, the third joint dull, scarcely longer than the second, broadly rounded, first two joints rather abundantly black pilose; arista reddish, yellow basally.

Mesonotum black, its sides before the suture and the postallar calli, salmon yellow, behind the suture translucent brownish reddish,

on the dorsum with three rather broad brownish yellow pollinose vittæ. The extremely short, appressed pile is yellowish. A broad stripe on the pleura before the wings yellowish, a similarly colored area below the humeri; the pleura elsewhere ferruginous and without pile. Scutellum yellowish at base and apex, its disc brownish ferruginous.

Legs yellowish red, the bases of the tibiæ yellow, all the femora with some tiny bristles beneath. Wings yellowish hyaline, broadly darker, more yellowish brown, along the costa.

Abdomen rather ferruginous, the second segment and base of the third more reddish-ferruginous, the first segment yellow, brown apically, the mammiform projections acute apically. Pile yellow on first three segments black on apical segments. The apex of the abdomen is oval, the expansion commencing from the base of the third segment, the second segment longer than the two following combined, cylindrical, of equal width, slender.

Holotype. ♂, Cuba (Baker) in Leland Stanford University Collection.

***Psilota fasciata* n. sp.**

Shining black, the abdomen with three reddish yellow fasciæ; legs partly reddish yellow. Length, 7 mm.

Male.—Head with rather thin silvery pollen, a vitta on the upper half of the face, most of the frontal triangle and the ocellar region bare; pile white, black on the vertical triangle, upper fourth of occiput and eyes, the lower fifth of the eyes with yellowish pile. Antennæ reddish yellow, the upper half of the third segment and the arista, blackish.

Thorax aneous on anterior half; pile yellow, a very broad band of black pile on the mesonotum between the wings, sometimes occupying the whole space between the suture and scutellum, the latter with yellow pile and with strongly impressed margin.

Tips of anterior four femora, their tibiæ and the first two segments of their tarsi, yellow, the basal two segments of the posterior tarsi yellow with the upper surface brown. Pile of legs yellowish, black on apical fourth of the femora and apical three tarsal segments.

Wings hyaline, the veins at the base and the stigma yellowish. Squamæ yellowish, the rim brownish except outwardly; fringe yellow. Halteres pale yellow.

Abdomen shining black; second segment yellowish on anterior two-thirds, the sides rather narrowly black, the yellow sometimes reaching narrowly to the lateral margins in front, and with a somewhat darker median vitta. Yellow band of third segment broadly interrupted in the middle, two-thirds as wide as length of segment; band on fourth segment reduced to a transverse, triangular yellow spot in either side at the base; the pale bands are well separated from the lateral margins. Pile yellow; black on the dorsum between the middle of the second segment and middle of the fourth. Second and third sternites and base of fourth, yellow.

Type male, and male *paratype*, Manila, Philippines (R. C. McGregor). Type in U. S. N. M.

Lepidostola colombia n. sp.

Black; antennæ brown, the first segment yellow; basal two segments of anterior tarsi and three segments of the posterior four, pale yellow; basal fourth of posterior femora reddish yellow. Length, about 6.5 mm.

Female.—Head shining black; the sides of the face broadly, an orbital spot opposite the base of the antennæ and another above the lower third of the front, sericeous; occiput, except the very broad upper border, yellowish grey pollinose; pile of occiput white, of vertex yellow, with a few black hairs above. Front strongly narrowed above, the vertex strongly produced upwards. Facial tubercle strong.

Thorax shining black, with a broad, median, thinly pollinose greyish vitta; the pleura, notopleura, anterior border of mesonotum and the posterior fourth, with scattered whitish squamulæ, the border behind the wings densely golden yellow squamose. Scutellum triangular, rounded apically, above with short, appressed black hair, the margin (below the tip) with some yellow hair. Mesonotum with inconspicuous, appressed black hair.

Legs with steel blue reflections; black haired, the femora with spines on basal half of lower edges; base of posterior femora and the pale tarsal segments, yellow haired.

Wings almost hyaline, yellowish in front, darker apically, the stigma yellowish. Squamæ white, with brownish border and fringe; halteres yellow.

First abdominal segment and narrow apex of the second, grey pollinose; second and third segments opaque black, with a very broad median vitta and the lateral margins, polished, the third with the apex moderately broadly shining and with a few squamulæ in the middle. Fourth segment shining black, with scattered whitish squamulæ. The pile of the basal two segments is yellow, on the apex of the second and on the following segments, black.

Holotype, female, Rio Frio, Magdalena, Columbia, July 13, 1927, (G. Salt), in Curran Collection.

The following key will aid in the recognition of the described species.

*Key to the Species of Lepidostola.**

1. Femora wholly black; abdomen not golden apically..... *colopus* Loew.
At least the basal fifth of the posterior femora reddish; if this color not sharply defined the apical two abdominal segments are golden..... 2.
2. Crossvein closing discal cell margined with brown..... *similis* Will.
Crossvein closing discal cell not margined with brown..... 3.
3. Wings with a narrow, incomplete, preapical brown fascia..... *pulchra* Will.
Wings at most weakly clouded with brown..... 4.
4. Apical two abdominal segments golden..... *abdominalis* Will.
Apical abdominal segments not golden..... 5.
5. Bases of anterior four femora yellow..... *perpolita* Johnson
Anterior four femora wholly black..... *colombia* Curran

**L. ortalina* Wulp, from Argentina, is omitted.

Cheilosia versicolor n. sp.

Similar to *illustrata* Harr. but the face bears black hair, the pile of the legs is differently colored, etc. Length, 12 to 14 mm.

Male.—Head black, greyish pollinose, the frontal and vertical triangles and the tubercle, thinly so; hair cinereous yellow, becoming more reddish on upper part of head; inner edges of facial side pieces, facial slopes, frontal triangle and vertical triangle except behind, black haired. Antennæ black; third segment small, semicircular, flattened above; arista black, short pubescent.

Thorax aeneous, the mesonotum behind the suture and the scutellum shining black, the pleura less shining below the wings, cinereous pollinose on anterior half. Pile pale yellowish to reddish yellow, black on the shining black portion, the posterior calli mostly and the free border of the scutellum broadly yellow pilose, the hair long. Scutellum without bristles.

Legs black; coxæ and anterior four legs black haired, the anterior coxæ with some pale hair basally on outer side; anterior four femora with short, tawny pile in front and long pale pile basally, their tibiae with tawny pubescence anteriorly; posterior legs with reddish yellow pile, that on the tibiae short and tawny, their tarsi black haired above.

Wings cinereous hyaline, sometimes with luteous tinge, a brownish cloud at the middle on the anterior half. Squamæ brown, with yellowish fringe; halteres with brown knob.

Basal half of second, whole of first and broad sides of the second segment, pale yellowish pilose, the abdomen elsewhere with long, tawny pile except on the broad sides of the third and narrow sides of basal half of the fourth segment, where the pile is thick and black. Venter pale haired on basal two segments, black haired beyond. The abdomen is aeneous, the basal segments somewhat hoary.

Female.—Front moderately wide, with a broad band of brownish grey pollen across the lowest fourth, the pile yellowish except across the ocelli, condensed laterally, the median third very thinly pilose above the pollinose band. Pile of legs more extensively pale, the black pile being limited to the lower posterior half and apices of the anterior four femora and the upper surface of the tarsi. In half the females there is no tawny abdominal pile, all the pile yellowish except for the black lateral areas on the third segment.

Type, male; *allotype*, female, and one male, seven females, Szechuen Province, China, (D. C. Graham). Types in U. S. N. M.

Rhingia lateralis n. sp.

Black; abdomen reddish with black lateral margins. Length, including snout, 12 to 13 mm.

Male.—Head black, the facial side pieces and a large, sub-triangular spot on the cheeks reddish; upper half of face, frontal orbits and the

occiput except above, greyish pollinose; pile black, pale around the posterior border of the oral opening; snout long, but little curved. Antennae reddish brown or brownish red.

Thorax bronze black, moderately greyish pollinose, with three broad, bare vittae; pile black, sometimes pale on hypopleura and sternopleura, the ventral scutellar fringe pale; no scutellar bristles, scutellum reddish.

Femora black, the apical third of the anterior four and fifth of the posterior pair, reddish; tibiae reddish, with very broad, blackish median bands; tarsi brown, the anterior four more or less reddish basally. Pile black, yellow on posterior surface of hind femora.

Wings with brownish tinge, normal in shape; squamae grayish white, with luteous border and yellow fringe. Halteres with brown knob.

Abdomen dark reddish, the first segment, a longitudinal, sub-triangular basal spot on second, a median vitta on the third, the lateral margins and genitalia, black; apical sternite sometimes blackish. Pile yellowish; black on the immediate sides, on genitalia and in the middle of the apical two sternites except at their bases.

Female.—Front wide, thinly grey pollinose across the middle; black pilose; less pale pollen on mesonotum; scarcely any black pile on sides of abdomen

Type, male; *allotype*, female; *paratypes*, two males, five females, Szechuen, China, (D. C. Graham). Types in U. S. N. M.

Key to the Indian Species of Crorhina

- | | |
|--|-------------------------------|
| 1. Bumble-bee like species | 3. |
| Apis-like species | 2. |
| 2. Posterior femora with a distinct tooth-like process below near the base; face with median dark vitta | <i>dentata</i> Brunetti. |
| Posterior femora simple, face without a dark vitta, shining brown on the lower half | <i>interrupta</i> Brunetti. |
| 3. Face shining brown or black with a narrow pollinose vitta on either side | 8. |
| Face not shining brown | 4. |
| 4. Tarsi wholly black or brown | 6. |
| Tarsi with at least the first segment wholly reddish | 5. |
| 5. All the tibiae reddish yellow; posterior femora with a large, low swelling below near the apex and a rather gentle sub-basal swelling; posterior tibiae normal (♂) | <i>pallidipes</i> n. sp. |
| Posterior tibiae mostly brownish, with a long, ventral excavation near the middle, their femora with a very large sub-basal swelling and without a pre-apical swelling below (♂) | <i>excavatus</i> n. sp. |
| 6. Middle tibiae ending in a spur (♂) | <i>imitator</i> Brunetti. |
| Middle tibiae not produced at the apex | 7. |
| 7. Femora black haired (♀) | (?) <i>imitator</i> Brunetti. |
| Femora yellow haired; spines at base of under surface of first segment of middle tarsi very long (♂) | <i>spinatarsis</i> n. sp. |
| 8. Face shining black with greyish lateral vittae (18 mm.) | <i>simioides</i> Brunetti. |
| Face shining brown with yellowish lateral vittae (15 mm.) | <i>virida</i> Brunetti. |

Criorhina pallidipes new species.

Tibiae and tarsi reddish yellow, the apical one or two tarsal segments brown; pile mostly yellowish. Length, 14 mm.

Male.—Face yellow in ground color; front and face densely golden yellow pollinose, the vertical triangle and occiput with greyish pollen; cheeks shining black. Antennae reddish; arista brownish on apical half. Pile of head yellow, on the anterior half of the vertical triangle, black. Eyes contiguous for a short distance.

Thorax moderately greyish yellow pollinose, the pile yellow, with a weak, broad band of black pile on the posterior half.

Femora black, with the apices broadly reddish. Pile of the legs yellow, black on the under surface of the posterior femora which are conspicuously swollen postero-ventrally near the base and on the under surface near the apex, the tibiae without apical spurs.

Wings cinereous hyaline; stigma brown. Squamæ whitish or cinereous. Halteres yellow.

Abdomen yellow pilose, the apex of the second segment broadly black haired except laterally; abdomen with greyish pollen except small basal triangles on the sides of the third segment.

Type, ♂, Deoban, Chakrata, India, Forest Entomologist's Collection, Dehra Dun.

Criorhina excavatus new species.

Mostly yellow pilose; tibiae and tarsi reddish, the posterior tibiae more than half brown, the apical two tarsal segments brown. Length, 14 mm.

Male.—Face reddish yellow in ground color; face and front golden yellow pollinose; cheeks shining black; occiput and vertical triangles with greyish yellow pollen; pile yellow, black on the anterior half of the vertical triangle. Antennae reddish.

Thorax yellow pollinose and pilose, the posterior half of the mesonotum shining black and black haired except a narrow prescutellar fascia and the posterior calli.

Femora black; anterior four tibiae with brownish post-median bands. Pile yellow, black on the upper surface of the anterior four femora, the upper surface of the posterior pair on the apical third, lower surface of posterior femora and on the apical two segments of the tarsi.

Wings cinereous hyaline, slightly brownish along the veins; stigma luteous. Squamæ greyish with yellow fringe, the upper lobe rather brownish. Halteres reddish.

Abdomen with greyish yellow pollen and yellowish pile, the apical third of the second segment except laterally, and the genitalia, shining black and black haired. Fifth sternite with short black hair.

Type, ♂, Deoban, Chakrata, India, in Forest Entomologist's Collection, Dehra Dun.

This species is readily separated from *pallidipes* by the shape of the posterior femora and tibiæ and the shining black genitalia of the male.

***Criorhina spinitarsis* new species.**

Similar to *imitator* Brunetti but the middle basitarsus bears six or seven spines sub-basally, each of which is longer than the thickness of the tarsus, and the femora are yellow pilose. Length, 21 mm.

Male.—Face and front greyish yellow pollinose, the cheeks, front of antennal prominence and the vertical triangle shining black, the latter thinly pollinose; pile yellowish, rather whitish on the lower part of the occiput. Antennæ black, the third segment missing. Eyes rather narrowly separated. Face strongly produced downwards.

Thorax with long yellow pile and yellowish pollen, the posterior half of the mesonotum, except a narrow prescutellar fascia, shining black and black haired.

Legs black; pile yellow, very short on the tibiæ and tarsi, rusty reddish on the lower surface of the tarsi, mostly blackish above. Middle and posterior tibiæ not produced; posterior femora moderately large; claws red on basal half.

Wings cinereous hyaline, with brownish tinge along the veins. Squamæ brownish, the lower lobe whitish with brown border. Halteres brown.

Abdomen black; first two segments with yellow, third with black, the fourth with long, tawny pile, the genitalia mostly tawny pilose, some of the hair black. Venter yellow pilose, the fifth sternite with short black pile except at the sides.

Type, ♂, Rishikesh, Dehra Dun, India, Dec. 18, 1918, in Forest Entomologist's Collection, Dehra Dun.

***Mallota salti* n. sp.**

Black, clothed with yellow and black pile; scutellum and tarsi reddish; wings brown with pale apex and posterior border. Length, 12 mm.

Female.—Anterior fourth of front, broad median facial vitta and anterior half of cheeks shining brown; face and occiput yellowish grey pollinose; front opaque black; pile of head wholly black. Antennæ black; third segment and arista reddish, the arista brown on basal fourth.

Thorax black pilose, the dorsum on the anterior half with reddish yellow pile, the upper part of the mesopleura similarly clothed, beneath the pale pile greyish pollinose, with obscure dark median vitta. Scutellum yellow pilose.

Legs brown; femora apically, broad bases and apices of the tibiae and the front tarsi reddish brown; middle and hind tarsi reddish; pile black.

Wings brown, the very broad apex and broad posterior border cinereous hyaline. Marginal cell broadly open.

First abdominal segment, base of second, apex of third and base of fourth, black pilose, the black pile triangularly produced forwards in the middle on the third segment and widening laterally on the fourth. Venter with yellow pile except on the basal sternite.

The pile in this species is somewhat longer than in *posticata* Fabricius.

Holotype, female, Vista Nieve, Santa Marta, Columbia, 5000 ft., February 10, 1927. (G. Salt), in Curran Collection.

Related to *M. margarita* Williston, and with almost similarly colored wings, but *margarita* lacks yellow pile on the thorax.

Mesembrius simplicipes n sp

Related to *platylarsis* Curran, but at once distinguished by the simple hind tarsi. Length, 13 mm.

Male.—Head golden yellow pollinose, the cheeks with paler pollen; pile golden yellow, black on the vertical triangle. Vertical triangle and a rectangular spot above the antennae black, the latter with a few black hairs; eyes touching for a short distance; antennae brown, the basal segments tinged with red.

Mesonotum dull black, with the lateral margins and two broad vittae reddish gray, the vittae broadly fused behind; the pleura mostly grayish pollinose. Pile reddish yellow, the lateral black areas behind the suture with coarser black hair, the disc of the reddish scutellum bearing short black hair.

Legs reddish; a broad stripe on the anterior femora above and the hind femora on basal three-fourths, black. Anterior femora broad, bearing short, black hair dorsally, laterally and posteriorly with rather short golden yellow pile, ventrally with dense, long golden reddish pile, the black hair becoming long posteriorly. Anterior tibiae broad except basally, with a large black spot on apex of under surface in front, two conspicuous tubercles situated in the black spot; the golden reddish pile is long and dense posteriorly, elsewhere short, on the black spot very short and black; in some lights this spot appears cyaneous. Anterior tarsi broad, the first segment wider than long, the posterior edge strongly produced, the segment mostly whitish; second segment produced on anterior apex, longer than wide, much narrower than first; third as long as wide; fourth twice as wide as long; hair black on dorsum of apical two or three segments, tawny on the sides and on basal segments. Middle femora robust, tapering on apical third, pale haired except on apical two-thirds of under surface; middle tibiae strongly arcuate on apical two-thirds, black haired ventrally, the hair long on

basal third, elsewhere with rather short, golden reddish pile; middle tarsi black haired. Posterior femora rather strongly thickened, tapering on apical third; black haired on apical third, expanding to half below, a few scattered black hairs extending to basal third, the ventral black hair coarse. Posterior tibiae arcuate, black haired, the hair dense and erect ventrally, a few pale hairs postero-dorsally. Posterior tarsi black haired. All the tarsi become blackish apically.

Wings cinereous hyaline, the squamæ, their fringe and halteres yellow

First abdominal segment black, gray pollinose; second with a broad median vitta, a broad, laterally tapering posterior fascia and a narrow, incomplete basal fascia black, opaque except the broad apex. Third segment black, with a pair of large, subrectangular, broadly separated basal reddish spots which reach the lateral margin in full width and are connected in front by a broad, gray pollinose fascia and narrowly so behind, bearing a roundish opaque black spot a little before the middle of the segment; behind the second pollinose band the segment is thinly grayish pollinose. Fourth segment with the basal half on the median two-fifths yellowish gray pollinose, the pollen enclosing a small, roundish opaque black spot. The pile is reddish yellow, only black on median half of the black posterior fascia on second segment, and on median fifth of black fascia on third segment; it is dense and erect on the fourth segment, especially towards the apex

Type, male, Great Oriental Forest, Madagascar, in California Academy of Sciences.

Mesembrius platytarsis n. sp.

Related to *tarsatus* Big. and *perforatus* Speis. from both of which it differs in the simple posterior tibiae. Anterior tarsi flat, broad, the first segment of the posterior pair more than twice as wide as following segments, deeply excavated on the anterior apex, the anterior corner of which bears a long, mammiform projection. Length, 13 mm.

Male.—Face yellowish white pollinose, the head elsewhere golden yellow, but the pollen becomes paler on the lower occiput; facial vitta, a spot on the frontal triangle anteriorly and the ocellar region, black. Pile yellowish, black on frontal and vertical triangles the sides of the former broadly pale pilose; antennae brownish black.

Thorax dull black; pleura yellowish gray pollinose; mesonotum with two broad, widely separated vittae and the lateral margins reddish yellow, the median vitta connected posteriorly by a broad, more grayish band in front of the scutellum. Scutellum reddish with blackish base. Pile reddish yellow, mostly black on the mesonotum behind the suture, and on the scutellum except the border.

Legs reddish, anterior femora with a median black streak above, the posterior pair black except on apical fourth, the tarsi becoming

ferruginous apically. Front femora broad, much wider than high, their posterior edge almost evenly convex; the pile golden reddish and fairly long postero-ventrally, elsewhere black, very short above; front tibiae rather broad, wholly golden reddish pilose; front tarsi broad, flat, the first segment whitish, sub-triangular, as long posteriorly as wide, anteriorly with three or four basally curved bristly hairs, and beneath with several brown ones, second segment as long as wide, the following two much shorter than wide; hair reddish laterally, black above. Middle femora swollen, on apical third of hind and apical half of front surface with short, black hair, that behind long above, elsewhere yellow pilose; middle tibiae yellow pilose, the under surface with short, black hair, their tarsi black haired. Posterior femora swollen, scarcely curved, pale haired, the apical third with black hair; no coarse black hair basally; hind tibiae compressed, simple, with short, black hair; hair of hind tarsi black. The middle tibiae are rather strongly arcuate on the apical two-thirds, the concavity beneath.

Wings grayish hyaline. Squamæ and fringe yellow; halteres reddish yellow.

First abdominal segment black, gray pollinose; second segment reddish yellow, with a broad median vitta, the rather broad base on the median half and the fairly wide apical margin, black, opaque except the narrow apex, the black narrowing laterally. Third segment shining black on apical third and with a broad, opaque black median vitta. Fourth segment grayish yellow pollinose on basal half, the sides broadly and the apical half shining brown, a small oval median spot in the pollen opaque black. The pile is yellowish, black on the black posterior fasciæ on the second and third segments, on the median vitta on the third and on lateral triangles which project forwards half way to the anterior corners on the second.

Female.—Front black pilose on whole length, pale pilose on sides of lower half; legs almost simple, the front femora only a little widened, the hind pair not as large as in male, pile as in male on front legs, wholly pale on middle femora and tibiae and mostly pale on hind tibiae. More than the lateral third of the basal two-fifths of the fourth segment is yellow; the third segment is gray pollinose on the median third behind the black vitta while the fourth bears an incomplete gray pollinose fascia behind the pale spots, but not touching them; fifth segment gray pollinose on basal three-fifths with a brown median spot; the second to fourth segments have the black fasciæ black pilose while the third and fourth are broadly black haired in the middle.

Holotype, male; *allotype*, female; Great Oriental Forest, Madagascar, in California Academy of Sciences.

Sericomyia completa n. sp.

Black, the thorax shining; abdomen with three narrow, entire, orange bands. Length, 17 mm.

Male.—Face perpendicular, the tubercle low but conspicuous; more than the lateral third of the face pale yellowish, the lateral fourth whitish pollinose; cheeks, occiput and front with cinereous pollen, the pile pale yellowish, black on frontal and ocellar triangles; occipital cilia black. Antennæ reddish brown, rays of arista black.

Thorax pale yellowish pilose, the pile much more conspicuous laterally and on the pleura; a broad band of black pile between the wings, the scutellum black pilose except on the border.

Coxæ and femora black, the broad apices of the latter and the tibiæ and tarsi reddish, the apical two or three tarsal segments brown, black haired. Posterior trochanter with angulate tubercle. Pile of legs pale. Posterior tibiæ conspicuously swollen, gently arcuate, their tibiæ more strongly curved.

Wings luteous anteriorly, rather brownish on apical third in front, hyaline behind, veins reddish. Squamæ whitish, their cilia brown. Halteres brown, with reddish stem.

Abdomen with three entire pale orange faciæ which do not quite reach the lateral margins, are very slightly bowed forward, the band on the second segment obscurely interrupted by a slender line, the bands all of the same width, about one-fifth as wide as the length of the third segment, and successively closer to the base of their respective segments, that on the third segment about its own width from the base. The pile is pale yellowish, the second and third segments each with a broad, incomplete band of black pile occupying the posterior third or more.

Type, male, Kiluno, Formosa, in California Academy of Sciences.

Key to the Species of Korinchia Edwards.

- | | |
|---|------------------------|
| 1. Scutellum wholly reddish in ground color | <i>rufa</i> H. B. |
| Scutellum black in ground color, the border yellow or brown | 2. |
| 2. Scutellum clothed with abundant appressed golden hair, the posterior border with several long, brown hairs | <i>aurata</i> H. B. |
| Scutellum largely black haired or the pile erect and sparse | 3. |
| 3. With a patch of yellow hair outside the posterior calli | 4. |
| With only dark hair outside the posterior calli | <i>monticola</i> Edw. |
| 4. Pile of scutellum largely blackish | 5. |
| Pile of scutellum wholly yellowish except for a few long brown hairs on the margin | <i>sinensis</i> n. sp. |
| 5. Fourth abdominal segment with a large, yellowish-gray patch on either side | <i>klossi</i> Edw. |
| Fourth abdominal segment without greyish patch | <i>robinsoni</i> Edw. |

***Korinchia sinensis* n. sp.**

Female.—Length, 13 mm.; face reddish in ground color, with a median brown vitta tapering above, wholly golden yellow pollinose; a vitta on the cheeks shining brown; supra-antennal shining brown spot rectangular; pollen of upper three-fourths of front and upper fourth of occiput brownish; pile of front and upper fourth of occiput black, elsewhere, yellow. Antennæ reddish, the basal two segments brownish red.

Thorax black; mesonotum with brownish ochreous pollen in front of the suture; humeri and a stripe running over the mesopleura golden yellow, the sutural fascia not much paler than the mesonotal pollen; pollen of the pleura greyish. Pile of thorax brassy yellow, not abundant, black on the mesonotum behind the suture and on the sides in front; scutellar pile yellowish with a few scattered black hairs apically, the border of the scutellum broadly yellow and yellow pollinose.

Legs reddish, the tibiae yellow on basal half or more; anterior tibiae black on anterior surface and on apical sixth, their tarsi wholly black; hair golden yellow except on black parts and apical one or two segments of the tarsi, the femora with some short black hairs apically on under surface.

Wings cinereous hyaline, with a grey cloud apically and a narrow, weak greyish fascia across the middle. Squamæ greyish, with brown border and yellow fringe; halteres yellow.

Abdomen rusty reddish, the second to fourth segments each with a brown median spot basally, that on second and third segments subrectangular, on the fourth, roundish. Pile pale golden yellow, black on the fifth segment and on the apex of the fourth, much more widely so in the middle, and a few scattered black hairs on the apex of the third; pile appressed, the pale hair fine. Sternites black with yellow posterior borders, the pile black on the apical two, elsewhere pale, wholly short and appressed.

Type female, Suifu, Szechuen, China (D. C. Graham), in U. S. N. M. *Paratype*, female, near Washan, Szechuen, China, 7-9000 ft., July 21, 1925 (Graham).

TACHINIDÆ.

***Signosomopsis townsendi* n. sp.**

Abdomen dark reddish with black median vitta and six pairs of white pollinose spots; legs reddish and yellow, wings brown. Length, 11 to 14 mm.

Male.—Head black, the face and cheeks yellow, head pale yellow pollinose, the front with less abundant greyish pollen; frontal vitta reddish. Hair of front, parafacials and upper part of cheeks, black, elsewhere yellowish. Front five-sixths as wide as eye; no ocellars; eight to ten pairs of frontals and two or three in a secondary row below; vertical bristles cruciate; outer verticals long; occipital cilia extending to lower fifth of eyes. Antennæ reddish, third segment black, about as long as the second; penultimate arisal segment three or four times as long as wide. Palpi represented by a bristle.

Thorax greyish pollinose, with olivaceous tinge above; the vittæ slender; scutellum reddish. Acrosticals 2-3; dorsocentrals 3-3; three intra-alars; sternopleurals 2-1; scutellum with two pairs of marginals and a very weak, cruciate apical pair, the disk with coarse, fairly abundant bristles and short hair; propleural hair black.

Femora reddish; tibiæ and tarsi very pale yellowish.

Wings brown; squamæ milky-white, the upper lobe with brown border. Halteres reddish, with brown knob.

Median black vitta of abdomen broad, not reaching the apex of the abdomen, the second to fourth segments each with a rather narrow basal white pollinose fascia which becomes weak laterally and widens on the venter, these segments each with a sub-triangular or sub-oval, white pollinose spot on either side of the vitta, the spots on the second segment reaching the apex of the segment. Hair black; second and third segments each with six to eight discal bristles forming an arched row in front of the middle, second segment with the marginal row interrupted on either side of the middle, the row on the third segment entire; fourth segment with bristles on a little more than the apical half, the bristles becoming weaker towards the apex of the segment; sternites with bristles. The abdominal bristles are strong but not blunt. Genitalia reddish.

Female.--Differs only sexually: Front one-fifth wider than eye; two pairs of orbitals; penultimate arisal segment two or three times as long as wide

Holotype, male, Matucana, Peru, 8000 ft., on foliage, Aug. 16, 1913, (C. H. T. Townsend), in United States National Museum.

Allotype, female, same data.

Paratypes, ten females, same data; four females, Jan. 29, 1913; two females, Sept. 8, 1912; female, "Bogota," in Canadian National Collection.

***Signosomopsis eronis* n. sp.**

Abdomen reddish with broad median black vitta and rather narrow white pollinose fasciæ on bases of segments; legs reddish, the tarsi yellow. Length, 12.5 to 13.5 mm.

Male—Face and cheeks yellow; head white pollinose, hair black, the occipital pile yellow; frontal vitta brownish; six to nine pairs of frontals, the upper pair divergent; cheeks one-half as wide as eye-height. Antennæ brownish red, third segment black, large; basal arisal segment short, the penultimate segment from three to five times as long as wide. Proboscis black, the palpi represented by a small bristle. Hair of parafacials black, of cheeks largely yellow.

Thorax with greyish pollen, that on mesonotum with ochreous or olivaceous tinge, in some lights brownish red posteriorly, the vitta weak; hair black. Acrosticals 0-1; dorsocentrals 3 or 2-3; three pairs of marginal scutellars and a pair of weak, cruciate apicals, the dorsum with a few short, spinous bristles; sternopleurals 1-1-1. Scutellum brownish red.

Femora and under surface of tibiæ black haired, the hair elsewhere yellow; tarsal bristles yellow.

Wings brownish, darker basally. Squamæ brown; halteres brownish red.

The pollinose abdominal fasciæ are obsolete laterally, but on the fourth segment the whole segment may appear pale yellowish pollinose from some views; the black vitta usually does not reach the apex of the abdomen. Second segment with a cluster of about eight pairs of spinose discals, the third with an arched row of about four pairs; fourth segment with bristles except basally. Bristles of sternites rather obtuse apically; lobes of fifth sternite brownish; genitalia reddish.

Female.—Hair of cheeks mostly yellow, of the tibiæ, black; differs only sexually.

Holotype, male, Ollachea, Peru, Feb. 2; *Allotype*, female, Uruhuasi, Peru, Feb. 15. *Paratypes*, male, two females, Uruhuasi, Feb. 3, 5, 1910, (C. H. T. Townsend). Types in U. S. N. M.

Dexodes nana n. sp.

Black, halteres yellow, the pollen cinereous. Length, 5.5 to 6 mm.

Male.—Pollen of head with silvery tinge, the parafrontals almost bare above, about fourteen pairs of frontals, the upper three reclinate, the two lower reclinate pairs strong; ocellars strong; outer verticals very weak. Front three-eighths as wide as either eye; the parafrontals about as wide as frontal vitta. Occipital pile white; cheeks black haired, two-ninths as wide as eye-height, parafacials narrowing below, at the middle much narrower than third antennal segment; four or five bristles immediately above the vibrissæ. Palpi black. Antennæ black; third segment moderately wide, the upper apex angular, lower apex rather sharply rounded. Arista thickened on basal fifth.

Pollen of thorax rather thin, especially on the mesonotum, the vittæ not conspicuous. Acrosticals 2-3; dorsocentrals 2-3; posterior sub-lateral absent; posthumeral weak three pairs of marginal scutellars and a pair of apical hairs; three sternopleurals. Hair of thorax black.

Legs black; middle tibiæ with a single antero-dorsal bristle; pulvilli elongate.

Wings with cinereous tinge, the base somewhat luteous; third vein with two or three weak basal bristles. Squamæ white; halteres yellow.

Basal two-fifths of second to fourth abdominal segments whitish pollinose, the pollinose bands broadly interrupted in the middle. First segment with pair of marginals, the others each with a row; second segment with one or two pairs of discals, third with an irregular row, the fourth with two rows.

Female.—Front a little more than half as wide as eye, two pairs of orbitals eight or nine pairs of frontals, the upper two pairs reclinate; outer verticals distinct. Pollen of front and thorax thicker. Pulvilli

short, second abdominal segment with one pair of discals, the row on the third segment not always complete.

Holotype male, *allotype* female and several additional specimens from Kaslo, B. C., June and July, 1903, (R. P. Currie), in United States National Museum. Paratypes in Canadian National Collection.

Key to the Australian Species of Prosenæ.

- | | |
|---|---|
| 1. Scutellum wholly dull black | 2. |
| Scutellum pale pollinose or pale in color | 4. |
| 2. Mesonotum with a broad, brown fascia behind the suture, otherwise pale pollinose (from posterior view) | 3. |
| Mesonotum black vittate | <i>vittata</i> Macquart |
| 3. Wings brownish on the apical half, paler brownish on basal half, | |
| Wings almost hyaline (Tasmania) | <i>argentata</i> Curran |
| | <i>rufiventris</i> Macquart |
| 4. Femora reddish or yellowish on at least the basal half | 5. |
| Femora black | 10. |
| 5. Abdomen without a median shining black vitta | 6. |
| Abdomen with the median vitta shining black | <i>dorsalis</i> Macquart |
| 6. Checks wholly white pollinose, without a reddish brown spot between the eye and oral margin | 8. |
| Checks with a reddish brown or dark spot extending from the eyes to the oral margin | 7. |
| 7. Mesonotum with an incomplete brownish fascia behind the suture, | |
| | <i>bella</i> Curran |
| Mesonotum vittate | 13. |
| 8. Mesonotum with fine, yellowish hair | <i>sibirita</i> Fabricius |
| Mesonotum with only coarse black hair, except on the sides | 9. |
| 9. Parafacials with distinct yellowish hair; front with black hair | <i>facialis</i> Curran |
| Parafacials without any trace of hair; front with sparse yellowish hairs inwardly | ♂ ♀ <i>malayana</i> Townsend; ♀ <i>sibirita</i> Fabricius |
| 10. Legs wholly black; pleura pale pollinose | 11. |
| Tibiæ reddish; mesopleura black pilose | <i>varia</i> n. sp. |
| 11. Mesonotum pale pilose; legs very long | <i>zonalis</i> n. sp. |
| Mesonotum black haired | 12. |
| 12. Scutellum wholly dark in ground color | <i>nigripes</i> Curran |
| Scutellum reddish | <i>scutellaris</i> n. sp. |
| 13. Tibiæ brown; frontal vitta black (Tasmania) | <i>dispar</i> Macquart |
| Tibiæ reddish; frontal vitta rusty reddish (Australia) | <i>variegata</i> n. sp. |

Prosenæ scutellaris, new species.

Black, the head and the basal three abdominal segments, except a median vitta, yellowish; pollen thick, cinereous, not tessellate. Length, 10 mm.

Male.—Head whitish pollinose, the occiput greyish, black in ground color, the front with yellowish tinge, the vitta rusty reddish. Front half as wide as either eye; eight pairs of frontals; ocellars long; occipital cilia extending to lower sixth of the eye; pile of occiput and cheeks yellowish, the latter with pile in front. Proboscis not quite twice as long as head-height. Antennæ yellowish; arista reddish brown.

Thorax with cinereous pollen dorsally, grey on the pleura; mesonotum black haired, the pleura yellowish pilose. Humeri and scutellum red-

dish. Dorsocentrals 2-3; sternopleurals, 1-1; three pairs of marginal scutellars and a pair of discals.

Legs black, the knees reddish; middle tibia with a fairly strong antero-dorsal bristle.

Wings cinereous hyaline, with luteous tinge anteriorly. Squamæ whitish with yellow border; halteres yellowish.

Median abdominal vitta broad, the fourth segment obscurely reddish laterally on its broad base. Abdomen almost evenly, coarsely cinereous pollinose, each segment with a transverse, bare, dark apical spot on either side. First segment without marginals, second with one pair, third with row of six, the fourth with eight. Abdomen with black hair except on the base of the venter.

Type, ♂, Neu Britannia, in Zool. Mus. Hamburg.

***Prosenia zonalis*, new species.**

Black, the abdomen with two or three broad, interrupted yellow fasciæ; mesonotum silvery from anterior view, with four vittæ which form a large, indefinite dark area behind the suture, from posterior view. Length, 9.5 to 10.5 mm.

Male.—Head yellowish, the occiput black in ground color, white pollinose, the occiput more greyish. Nine or ten pairs of frontals; occipital pile sparse, yellowish. Cheeks two-ninths as wide as eye-height, yellow haired; face and cheeks separated by a broad rusty brownish stripe. Proboscis one-third longer than head-height. Antennæ reddish. Front two-sevenths as wide as either eye.

Thorax densely greyish white pollinose, yellowish pilose. Scutellum black with reddish apex, clothed with grey pollen and black hair. Dorsocentrals, 3-3; sternopleurals 1-1; three pairs of marginal scutellars, the apical pair cruciate.

Legs very long, black; coxæ silvery grey pollinose.

Wings cinereous hyaline, somewhat brownish on the apical half, conspicuously so in front. Squamæ white; halteres yellow.

Abdomen opaque brown, the basal three-fifths of the second and third segments yellowish except for a median vitta, the pale areas and the fourth segment except its tip, silvery greyish pollinose. First segment without dorsal bristles, the second with a pair, the third and fourth each with a row of marginals. Hair black on the dorsum, yellowish on the under part of the first three segments and on the yellow pollinose genitalia.

Female.—Front four-fifths as wide as either eye, with two pairs of orbitals and a few obscure, yellowish hairs; dark mesonotal vittæ appearing brownish; fourth abdominal segment reddish on the basal half; legs shorter; mesonotum black haired.

Holotype, ♂, allotype, ♀, and 3 ♂ paratypes, Tonga. Types in Zool. Mus., Hamburg.

***Prosenia variegata*, sp. n.**

Black, the abdomen chiefly reddish, legs reddish, tarsi black; wings cinereous or brownish hyaline. Length, 10 to 12 mm.

Male.---Head reddish, the occiput black; pollen whitish, on the occiput above and on the front with yellow tinge; nine or ten pairs of frontals with yellow hairs between them; frontal vitta brownish red, obsolete above; ocellars long; the black occipital cilia extend almost to the lower edge of the eyes; pile of the occiput and cheeks yellowish, distinct on the anterior part of the cheeks; cheeks almost one-third as wide as eye-height, with rusty band across the middle. Proboscis one-seventh longer than head-height; antennæ orange; arista brown.

Thorax grey pollinose, with ochreous tinge dorsally and with four distinct vittæ; humeri largely reddish; scutellum reddish on apical half; pleura pale pilose, the mesopleura about half, the humeri and dorsum black haired. Dorsocentrals 3-3; sternopleurals, 1-1; 3 pairs of marginal scutellars, no discs.

Legs very long, reddish, the tarsi black. Squamæ whitish. Halteres reddish.

Abdomen reddish, the depression and sides of the first segment, a median vitta, a broad lateral band on the second segment, the apical fourth of the third and the whole of the fourth, black, the pollen rather abundant, tessellate, whitish, covering almost all the fourth segment, the other black areas opaque except the median vitta which is pollinose on the anterior three-fourths of each segment and shows a brownish pollinose median line. First segment with a pair of long marginals, the second with six, the median pair of which is well separated from the others, the third and fourth segments each with a row of marginals. Hair sparse, black, yellow on the basal half of the venter; genitalia grey pollinose

Type, ♂, Gravesend, Queensland, 15.v.1925 (J. Mann); paratypes: ♂, same data and ♂, Australia, (Schrader).

***Prosenia varia*, sp. n.**

Rather slender; black, face and cheeks yellow; sides of the basal three abdominal segments reddish; mesonotal vittæ rather weak; legs black, the tibiæ reddish. Length, 9 mm.

Male.---Head white pollinose. Front one-fifth as wide as either eye; ocellars long and strong; nine or ten pairs of frontals; some long black hair above; the occipital cilia extend as a row of fine hairs across the cheeks; pile of the occiput and cheeks yellow, the latter without hair in front, with an orange stripe across the middle. Proboscis more than one and one-half times as long as head-height. Antennæ orange; arista brown basally, its rays brown.

Thorax ashy pollinose, the four vittæ distinct from posterior view; hair of the mesopleura, humeri and dorsum black; scutellum wholly dark; pile of pleura yellow. Dorsocentrals, 2 or 3-3; sternopleurals, 1-1; 3 pairs of marginal and a pair of discal scutellars, the hair of the scutellum long.

Legs blackish, the tibiæ reddish. Wings with brownish tinge. Squamæ slightly greyish, with yellow border. Halteres reddish.

Basal three abdominal segments with a very broad median black vitta, the sides reddish, the second segment with narrow, the third with broad posterior border brownish or black, the whole abdomen rather thickly cinereous pollinose, the apices of the segments broadly subshining on the sides, the pollen sub-tessellate. First segment with a pair of long marginals, the second with stouter pair, the third and fourth segments each with a row. Hair black, yellow on the venter of the basal two segments. Along the broad middle line the pollen has a strong brownish cast.

Type, ♂, New South Wales, (Schrader).

DESCRIPTIONS OF NEW OR INADEQUATELY KNOWN AMERICAN SPIDERS.

(Second Paper).*

ALEXANDER PETRUNKEVITCH,
Yale University.

Order MYGALOMORPHAE

Family Ctenizidae

Pachylomerus carabivorus Atkinson

(Plate I, Figs. 1 to 9).

(a) *Female* from Rome, Georgia, collected by Mr. H. B. Bilbro in March, 1918

Total length with chelicerae 27.0 mm. *Carapace* 10.0 mm. long, 9.0 mm. wide, narrower behind than in front and almost hexagonal in shape (Pl. I, Fig. 1). Thoracic groove procurved, semicircular, deep; the vertex of the semicircle exactly $\frac{1}{3}$ from posterior margin. The head slopes steeply toward the groove. Posterior border of groove evenly rounded, anterior border rather angular. Neither cephalo-thoracic sulcus, nor the radiating thoracic sulci well developed, yet clearly indicated by the darker color of the chitin. A narrow band of chitin around entire margin of carapace quite white. Surface of carapace glabrous, with black bristles only in the following places: a tuft of about 18 bristles in front of AME, the four stoutest forming the usual transverse row; Irregularly arranged bristles filling the space between AME and PME; a row of middorsal bristles beginning at the anterior edge of the eyetubercle and extending back to about half the distance to the thoracic groove; this row is accompanied by flanking bristles in its anterior portion, but further back consists entirely of a single row. Finally, a pair of lateral bands of bristles extending on each side from the posterior eyes back as far as the middorsal row, but slightly diverging and composed of from 2 to 4 bristles abreast.

Eyetubercle rather low, short and wide, with the PME alone on the level of the surface of the tubercle. These eyes are of the nocturnal type. AME are raised on a joint tubercle of their own and each lateral eye is situated on a tubercle of its own. (Fig. 2). Eyetubercle 0.935 mm. long, 1.955 mm. wide. First row of eyes procurved, second row slightly, but distinctly recurved and a little longer. Ratio of eyes AME : ALE : PME : PLE = 7 : 12 : 9 : 11. AME separated from each other by $\frac{1}{2}$ of their diameter, from ALE by $\frac{1}{4}$ of their diameter, from PME by $\frac{1}{2}$ of their diameter, from edge of clypeus by $\frac{3}{4}$ of their diameter. PME separated from each other by $\frac{2}{3}$ of their long diameter,

*First paper published in the *Annals* for September, 1925.

from PLE by $\frac{1}{2}$ of their long diameter. Laterals separated from each other by $\frac{1}{2}$ of the diameter of ALE. Quadrangle much wider behind than in front in ratio 41 : 23, wider than long in ratio 41 : 22. A straight line passing through the centers of the AME and PLE of the same side touches the anterior edge of the PME (Pl. I, Fig. 2). A straight line passing through the ALE of one side and the PLE of the opposite side cuts also the AME of the same side with the ALE and the PME of the opposite side, though not through their centers (Pl. I, Fig. 2).

Chelicerae powerful, curved in front, flat on prolateral surface. A longitudinal band of bristles, beginning with a single bristle opposite ALE runs widening toward the distal end of the basal joint. Another, narrower band begins with a single bristle at base of chelicerae in middle of outer surface, half way distally begins to widen and merges with the apical area of bristles before the rastellum. A third row of bristles, single file, begins near base almost on outer visible edge and merges distally with the apical area. Rastellum well developed, composed of numerous short stout spines. It begins about $\frac{1}{4}$ the width of the fang from its retroarticulation. In middle a regular projection is formed, extending to proedge of chelicerae (Pl. I, Fig. 3). Promargin with a somewhat irregular row of teeth of different size. There are 8 teeth on the left and 10 on the right chelicera, the extra two being proximal and very small. Retromargin with a row of 6 more or less equidistant and equal teeth. Scopula on both margins, but rather light. Lip wider than long in ratio $\frac{23}{17}$, narrowed in front where its truncated edge measures only $\frac{1}{23}$, i.e. about one-half its greatest width. The lip is convex longitudinally and transversely and is separated from the sturnum by an almost semicircular sulcus, but a suture is not present, the lip being immobile. At the end of the lip a group of about 14 cuspules is situated, each cuspule in its own socket. Surface of lip clothed with more or less evenly spaced black bristles.

Coxae of *pedipalpi* devoid of maxillary processes and the trochanter is inserted at the end of the coxa. A band of black cuspules extends from basal proangle diagonally to middle of coxa. Small brown cuspules cover distal end of coxa changing gradually into short bristles as they reach middle of coxa. Surface in front of black and brown cuspules is occupied by the scopula which is composed of fine, soft, brown hair without any definite arrangement. Long bristles clothe the base of the coxa, while the surface facing the first coxa is quite smooth. *Sternum* slightly longer than wide in ratio 70 : 62, widest between second and third coxae, narrowed in front to width of lip, pointed behind. Sigilla wanting, but immediately behind lip a band of modified chitin extends across entire sternum, in a curve. Sternum sparsely clothed with black erect hair along the edge, but is almost free from hair elsewhere.

First pair of *coxae* longest and more slender than the others, being twice as long as wide. Third coxae shortest, measuring only a little more in length, than in width, the ratio being 37 : 30. All coxae sparsely clothed with hair, those of the first pair entirely so, those of the second pair have a small bald spot near base; those of the third pair have two

large bald spots separated from each other by a longitudinal band of hair. Fourth coxæ similar to the third pair and are contiguous. *Trochanters* of palpi present in apical half, below, a somewhat raised, yellow area clothed with bristles many of which are modified as elongated, sharp-pointed cuspules. Trochanters of first and second pair of legs have a similar raised area, though of smaller size and clothed only with black bristles. Third and fourth trochanters are clothed with curved hair near apex. Above, third trochanters have a chitinous hook which is not quite middorsal in position and is directed toward the carapace. Fourth trochanters are peculiarly compressed at their proximal end. Third and fourth *femora* are much heavier than the others and almost naked below, while the other femora are clothed with erect, stiff, black hair. Above, all femora have a middorsal and two lateral bands of black, stiff hair, leaving between them two longitudinal, bald areas.

First and second *patellæ* are similarly clothed above. Patellæ of palpi are clothed in the same manner, but have in addition three or four cusps on inside near apex. Fourth patellæ have a longitudinal middorsal bald area and are covered with cuspules which change gradually into bristles toward apical end of joint. Third patellæ have two longitudinal bald areas and in addition to the black bristles have short spines or cuspules on prolateral surface.

Tibiæ of palpi as well as first and second tibiæ have two longitudinal bald bands and are densely covered laterally with peculiarly modified spines shown in Fig. 4. Similar spines cover the sides of first and second metatarsi and tarsi and of the terminal joint of palpi. Third tibiæ above with the saddle-like excavation peculiar to the genus and are covered at distal end with short, stout, blunt spines. Third metatarsi are almost entirely covered above with similar spines, while on the tarsi there are only a few spines above and below. Third tibiæ have a pair of ventral apical spines of the normal type. Fourth tibiæ have two longitudinal dorsal bald bands and are clothed on prolateral surface above with long hair, lower down with common spines which extend almost to ventral mid-line. Fourth *metatarsi* have a single dorsal bald spot near base and are clothed with common short spines prolaterally down to midventral line. Fourth *tarsi* have prolaterally similar spines and below long stiff hair not definitely arranged. Claws three; upper claws similar, with a single tooth (Pl. I, Fig. 5). Third claw smooth. Palpal claw with a large tooth and a much smaller one between the latter and the end. (Pl. I, Fig. 6). Legs 4132.

	<i>Femur</i>	<i>Patella</i>	<i>Tibia</i>	<i>Metatarsus</i>	<i>Tarsus</i>	<i>Total</i>
I	5 610	3 910	3 570	2 550	1 785	17 425
II.	5 270	3 825	2 975	2 380	1 785	16 235
III.	4 930	3 570	3 400	2 465	2 295	16 660
IV.	6 800	4 165	3 995	3 825	2 295	21 080
Palp	5 525	3 230	3 570	2 975		15 300

Abdomen finely mottled above and below with little pimplelike elevations for each individual hair, and with numerous small bald areas between. *Spinnerets* four, situated almost in a row. Anterior

pair slender, short and single-jointed, not quite as long as basal joint of posterior spinnerets. These are much heavier, three-jointed with joints shorter than their diameter. Terminal joint small, hemi-spherical. Small spinning tubes cover entire tip of anterior spinnerets, while a single large spigot is situated in the center of their truncature. In the posterior spinnerets small spinning tubes cover a ventral segment of the basal joint, entire ventral surface of the second joint and the entire terminal joint. Large spigots on the posterior spinnerets are distributed as follows: on the basal joint four in a transverse row at apex; on the second joint five in an apical transverse row, five in a median transverse row and a single prolateral, or eleven in all; on the terminal joint a single spigot. There are therefore altogether $4 + 11 + 1 = 16$ large spigots on each posterior spinneret. *Color* in alcohol: dark brown with dark grey abdomen. Below lighter, with the four lungs and the spinnerets yellowish brown.

(b) *Female* from Dead Run Swamp, Va., near Plummer Island, collected by H. S. Barber on April 10, 1917, a few inches under the ground in a nest with numerous young.

Total with chelicerae 16.7 mm. Carapace 7.225 mm. long, 6.460 mm. wide. Thoracic groove slightly more than two-thirds from anterior margin. A few bristles in front of eyegroup and those behind it in single rows. Eyegroup shown in Pl. I, Fig. 7, almost rectangular, one and one-half times as wide as long. First row of eyes not quite as long as second. A line passing through the centers of ALE and PLE of the opposite sides cuts AME of the former and almost touches anterior edge of PLE of the latter. Ratio of eyes AME : ALE : PME : PLE = 8 : 15 : 8 : 13. AME separated from each other by $\frac{1}{2}$ of their diameter, from ALE by $\frac{1}{2}$ of their diameter, from PME by $\frac{1}{2}$ of their diameter, and from edge of carapace by $\frac{2}{3}$ of their diameter (i.e. by three diameters). PME are separated from each other by $\frac{1}{2}$ of their long axis, from PLE by $1\frac{1}{2}$ of their long axis. Laterals are separated from each other by $\frac{1}{2}$ of the diameter of AME. Quadrangle wider behind than in front in ratio 30 : 22, wider than long in ratio 30 : 21. *Trichobothria* on all tarsi in two rows, a few trichobothria on metatarsi and a single one on the saddle of the third tibia. Club-shaped hairs on tarsi present. Retrolateral spines on fourth tarsi arranged in an oblique row. Hooks on anterior legs and palpi arranged more regularly. Lip with only four cusps.

(c) *Female* in my own collection, locality unknown.

Total with chelicerae 29.0 mm. Carapace 11.8 mm. long, 10.5 mm. wide. Eyegroup wider than long in ratio 78 : 37, i.e. a little more than twice as wide as long, but otherwise of the same type as in the other specimens. Ratio of eyes AME : ALE : PME : PLE = 10 : 19 : 12 : 14. Clypeus $\frac{1}{10}$ of the diameter of AME. AME separated from each other by their diameter and equally so from ALE and PME. PME separated from each other by $\frac{3}{2}$ of their long axis, from PLE by

$3\frac{1}{2}$ of their long axis. Laterals separated by $\frac{1}{10}$ of the diameter of AME. Quadrangle wider than long in ratio 52 : 30, wider behind than in front in ratio 52 : 29. The comb on the retrolateral surface of the fourth tarsi fully developed and shown in figure 8.

(d) *Young specimen from Dead Run Swamp.*

Total with chelicerae 3.230 mm. *Carapace* 1.360 mm. long, 1.275 mm. wide. Thoracic groove semicircular, two-thirds from anterior edge. Bristles and hair as yet little developed and in single rows in the places where in the adult they form bands. Thus in front of AME there are only three bristles in a transverse row. The middorsal row behind the eyegroup is formed by only four bristles and does not reach thoracic groove. A pair of lateral bristles on the level of the fourth middorsal bristle represent the lateral bands of the adult. There are no other bristles on the carapace, nor is there any hair. Rastellum composed of only two strong spines on the one chelicera and three spines on the other. Promargin with four teeth, retromargin with four teeth, all far apart. Only two cuspules on the lip and these, like those on the maxillae, are relatively longer than in the adult. On the maxillae there are only few cuspules and they are not arranged in any definite manner, in fact there are nearly twice as many cuspules on the one maxilla as on the other. There are also a few short spines present. Third trochanters with a long flap representing the hook of the adult. Modified spines or hooks on palpi and first and second legs still wanting. Instead, definitely arranged spines of considerable length are present on all legs.

On the palp the spines are distributed as follows: Femur-prolateral 1 apical, elsewhere 0; Patella—prolateral 1, elsewhere 0. Tibia—prolateral 1-1-1, retrolateral 1-1-1, elsewhere 0. Terminal joint, prolateral 1-1-1, retrolateral 1-1-1, elsewhere 0. The palpal claw is long and has a bifid tooth at base. On the legs the spines are distributed as follows: First leg—Femur, 0; Patella 0; Tibia—dorsal 0, prolateral 0-1-0, retrolateral 1-2-1, ventral 1 in middle. Metatarsus—prolateral—1-1, retrolateral 1-2, elsewhere 0; Tarsus prolateral 1, retrolateral 1, elsewhere 0. Second leg—same as first except: Tibia retrolateral 1, Metatarsus retrolateral 1-1, Tarsus—retrolateral 1-1. Third leg, Patella has two prodorsal apical spines. Tibia has the characteristic saddle-shaped depression and two prodorsal apical spines. Metatarsus has two prodorsal apical spines. Fourth leg—Patella has several dorsal spines with a bald space between them. Tarsus has several spines near distal end on ventral surface. Claws three; upper claws slender, with a single, very small tooth. Third claw smooth. A single trichobothrium on tibiae, two on metatarsi and several on tarsi.

Tarsi proportionately longer than in the adult. Thus third metatarsus is 0.850 mm. long, and third tarsus 1.360 mm.; fourth metatarsus 1.275 mm. and fourth tarsus 1.020 mm. Abdomen still shows clear traces of segmentation above and below, marked by differences in coloration. The eyegroup is shown in Fig. 9. Compared with the adult, the ratio of eyes is in favor of the laterals and there is a somewhat different arrangement due to closer approximation of the laterals.

General Considerations.—From a comparison of the described specimens one is led to the conclusion that *Pachylomerus carabivorus* is a rather variable species. The eyegroup is subject to considerable variation, including such as is caused by difference in age. The distribution of bristles is more or less permanent, but their number increases considerably with age. The cuspsules, especially those on the palpi and on the first and second pair of legs appear mostly later in life. The comb on the fourth tarsus may be present or wanting in the adult and is not yet present in the young. The shape of the carapace is also subject to change with age, but the ratio between its length and width and the position of the thoracic groove are permanent.

2. *Myrmekiophila fluviatilis* (Hentz).

(Plate I, Figs. 10, 11, 12).

Syn. *Myrmekiophila foliata* Atkinson. Entomol. Americana, 1886, Vol. 11, pp. 131-133, Pl. V, ff. 6, 7, 12 and 14. Female.
Comstock, Spider Book, 1912, p. 239, f. 222. Male.

Comstock gives only a very brief description and a figure of the male, but neither of its palp, nor of the eyegroup.

The single specimen described here has been captured by Professor W. J. Baerg, on December 16th, 1928, at Fayetteville, Arkansas.

Male.—Total length with chelicerae 11.0 mm. Carapace 6.0 mm. long, 5.3 mm. wide between second and third coxae, 3.1 mm. wide in front. It is nearly hexagonal, with anterior and posterior margins straight and the latter but a trifle shorter than the former. Thoracic groove deep, transverse, slightly procurved and almost, though not quite two-thirds from anterior edge. Thoracic portion of carapace quite flat. Head considerably elevated toward eyegroup which forms the highest region and is set in black pigment forming a transverse rectangle which is about one-third as long as the carapace is wide at anterior edge. PME irregular in outline and silvery. Arrangement and relative size of eyes is apparent from Pl. I, Fig. 10. First row procurved with medians closer to each other than to laterals and separated from each other by less than their radius. Second row recurved with PME wide apart. Edge of carapace with short, stout, black bristles.

Chelicerae powerful, with a longitudinal band of stout, short, black bristles in front. Rastellum on a cone-shaped protuberance (Pl. I, Fig. 11) with a group of very short spines at the end, of which only four anterior ones are shown in the drawing. These spines are arranged in a single row along inner edge of basal joint of chelicerae for some distance. Promargin with seven black teeth, alternately larger and smaller ones. Retromargin with five or six minute granules in proximal

half. Scopula on promargin only and quite light. Fang long, curved, dark reddish-brown. *Lip* immobile, fused with sternum, much wider than long, emarginate at tip. There are a few bristles, but no cuspules on the lip. *Sternum* (without lip) longer than wide in ratio 35 : 30. It is widest between second and third coxæ, gradually narrowed anteriorly to width of lip, neatly pentagonal posteriorly.

First coxæ wide apart, fourth coxæ contiguous. *Maxillæ* rectangular, not quite twice as long as wide. Upper inner angle slightly produced. There are a few cuspules at base. Scopula very light. All trochanters, but especially those of the palpi are with a distinct ventral hump toward end. Femora of the third pair of legs much stouter than the others. First metatarsus abruptly and peculiarly swollen in distal two-fifths. In the palp the tibia is much heavier than the other segments and has near its distal end a peculiar semicircular dilation on the retrolateral surface, possibly of sexual or fossorial function. Legs 4123.

	<i>Femur</i>	<i>Pat. + Tibia</i>	<i>Metatarsus</i>	<i>Tarsus</i>	<i>Total</i>
I	5 5	6 6	3 3	2 8	18 2
II ..	5 1	5 7	3 3	2 5	16 6
III	3 8	4 2	3 3	2 5	13 8
IV	5 5	6 6	4 8	2 8	19 7

Width of first patella at the knee 1.12. Tibial Index 16.

Width of fourth patella at the knee 1.12. Tibial Index 16.

The hair clothing the legs is spine-like and varying in length and stoutness and the true spines themselves are numerous and irregular in arrangement. There are some spines even on the fourth tarsi, although the other tarsi are without spines. Trichobothria in two rows on tibiæ, metatarsi and tarsi, but the rows are not regular. Upper claws not quite similar, although both pectinated in a single row. But the row is retroventral in the proclaw and proventral in the retroclaw. Third claw quite small and smooth. Abdomen ovoid, sparsely clothed with shorter and longer spine-like hairs. Spinnerets 4. Posterior pair heavy, three-jointed, separated from each other by slightly more than the diameter of the basal joint. Third joint small, almost hemispherical. Anterior pair situated between posterior spinnerets, small, separated from each other by almost their diameter. Pedipalp rather long and peculiar in appearance inasmuch as its femur is much more slender than the tibia. The embolus (Pl. I, Fig. 12) has a row of strong teeth along its edge. *Color in alcohol*: light rufous. Abdomen light grey-brown. Fang dark reddish-brown. Embolus black. Spines on legs black.

Family Theraphosidæ.

3. *Eurypelma marxi* Simon.

(Plate I, Fig. 13).

Male.—Total length with chelicerae 20.0 mm. Carapace 9.4 mm. long, 8.5 mm. wide, quite flat, clothed with short, black hair through which the red color of the chitin itself is readily visible. Edge of

carapace densely fringed with long, black hair. Thoracic groove deep, transverse. Eyes small, situated on a small tubercle, entire eyegroup rather unusually small for the genus. Both eyerows equally long. Anterior row well procurved, posterior row slightly recurved. Ratio of eyes AME : ALE : PME : PLE = 6 : 8 : 6 : 8. AME separated from each other by $\frac{1}{2}$ of their diameter, from ALE by their radius. PME oval, twice as long as wide, widely separated from each other and separated from PLE by less than half of their short axis. Laterals separated from each other by the diameter of the AME. Quadrangle wider behind than in front, wider behind than long in ratio 21 : 14. AME separated by two diameters from anterior edge of carapace. Heavy, black bristles on eyegroup.

Chelicerae with heavy black hair above, with fine, long, recumbent hair on outside, and with still finer, short, recumbent hair on inside. Promargin with 9 strong, black teeth. Retromargin smooth. A red scopula on retromargin. *Lip* wider than long, with numerous spinules at tip, with long, black hair. *Maxillae* with numerous spinules at inner angle near base. Inner apical angle rather long. Scopula salmon-colored. Behind lip two red areas corresponding to sigilla. *Sternum* slightly longer than wide, egg-shaped, narrower in front than behind, covered with long black hair. Four submarginal sigilla.

Inner surface of coxae without the fine, short spines characteristic for the genus *Dugesia*. All tarsi scopulate to base. First and second metatarsi also scopulate to base, third metatarsi in anterior half, fourth metatarsi only in distal third. All scopulae entire. Legs 4123. First leg 30 mm. second—27 mm., third—25 mm., fourth—32.3 mm. Tibia of first leg with two hooks: outer hook much larger and curved inward, inner hook small, with a spine at base almost as long as the tooth itself.

Spines. *First leg*—One apical midventral on patella; tibia—dorsal 0, prolateral 1-1, retrolateral 1-1-1, midventral 1-1-1. Metatarsus two apical ventral spines. Elsewhere 0. *Second leg*—Tibia—dorsal 0, prolateral 1-1, retrolateral 1, ventral 2-4 (the four apical). Metatarsus—1-3 ventral. Elsewhere 0. *Third leg*—Several spines without definite arrangement on the ventral surface of the tibia and metatarsus. *Fourth leg*—Numerous spines without definite arrangement on the ventral surface of the tibia and metatarsus and a verticillum at end of metatarsus. Heavy dorsal bristles at base of all femora, but especially on the first pair. Legs very hairy. Dorsal spines wanting. Claws concealed by the claw-tufts. Tibia of pedipalp much stouter at base than at end (Pl. I, Fig. 13), with two spines on the prolateral surface and a heavy ventral brush of long black hair. Bulb with long sharp point.

Organs of stridulation completely wanting.

Color in alcohol. Carapace red with black margin. *Chelicerae* dark red-brown. Abdomen black. Legs black with bald red longitudinal stripes on femora. Below, reddish brown with legs black beyond ends of femora. *Maxillae* and lip yellow.

One male captured by Miss Brenda Putnam in Colorado.

4 ***Cyrtopholis bartholomei*** (Latreille).

(Plate I, Figs. 14, 15, 16)

Syn. *Mygale incana* C. Koch, 1842.*Crypsidromus gypsator* Becker, 1879.*Cyrtopholis antillana* Thorell, 1894*Cyrtopholis venatorius* Pocock, 1903, Simon, 1903.*Cyrtopholis acutispina* Strand, 1906.*Cyrtopholis pelus* Chamberlin, 1917.*Cyrtopholis bartholomei* (Latreille) Strand, 1906, Petrunkewitch, 1926

This is the common *Tarantula* found in Saint Thomas, West Indies, and described under different names as the above list of synonyms shows. No other *Tarantula* occurs on the island. To my detailed description of the female, given in my paper on the spiders of the Virgin Islands, I now may add the description of a male captured by Arthur Lindborg on April 11, 1928, in front of the Grand Hotel in Saint Thomas.

Male —Total length with chelicerae 34.0 mm. *Carapace* 16.0 mm. long, 14.0 mm. wide between second and third coxae, 9.0 mm. wide in front, flat, with squarely truncated anterior margin. Thoracic groove in the shape of a deep, transverse depression situated two-thirds from anterior edge. Eyetubercle transversely ellipsoidal, marginal. First row of eyes procurved, second row recurved and as long as first. (Pl. I, Fig. 14). AME alone round. Several bristles on eyetubercle. Surface of carapace clothed with recumbent, short, woolly, brown hair. Anterior edge fringed with long, buff hair. Lateral margins fringed with long, fine, light-brown hair and stout, dark-brown bristles.

Chelicerae powerful, clothed with dark brown hair and bristles which are lighter toward end. Promargin with 13 teeth of which the proximal third and fifth are quite small. Retromargin smooth. A heavy scopula on both margins. Retrolateral surface of chelicerae smooth, without modified hair. Fang long and slender. *Maxillae* with distinctly produced inner upper angle. They are clothed with long bristles, and have numerous cuspules in basal third. Scopula well developed. *Lip* wider than long, with semicircular base and almost squarely truncated end. Numerous cuspules in distal quarter. Anterior edge of lip fringed with bristles. Surface of lip clothed with bristles of uneven length. *Sternum* flat, longer than wide, densely clothed with short, greyish-brown hair and long, stout, dark brown bristles. Posterior sigilla elongated, much nearer to lateral margins than to each other, separated from the margins by their own length.

Coxae clothed in the same manner as sternum. First coxae separated by more than the width of the lip, fourth coxae contiguous. Retrolateral surface of the trochanter of the pedipalp and the prolateral surface of the trochanter of the first leg with a heavy brush of modified bristles, forming a *lyra*. Tibia of first leg with two apical, ventral hooks at end (Pl. I, Fig. 15) which are of the same type as in *Cyrtopholis portoricae*. The larger hook is midventral, curved, and bears two

blunt spines, one of which is almost at the end, the other somewhat behind the first. The smaller hook is proventral in position and has a single blunt spine closely applied to it. The spines on both hooks may be seen only when the hair covering the hooks has been removed. All tarsi scopulate to base, but only the scopula of the fourth tarsi narrowly bisected by a row of a few short bristles, the other scopulae being entire. First and second metatarsi scopulate to base, third metatarsus in distal half, fourth only at end and at that quite lightly. Legs clothed with short, recumbent, dark hair, with very long, stout hair which is almost white toward end, and with short, almost white hair which forms a fringe at the end of each joint and also the longitudinal lines as follows: a fine prolateral line on the first and second femora, two dorsal lines on all patellæ and tibiae, and a middorsal line in the proximal third of all metatarsi. The lines of the first and second patellæ are fairly parallel, but on the third and fourth patellæ the pro-dorsal line passes in middle to the retro-dorsal side and takes the place of the retro-dorsal line which extends only from proximal end to middle of patella. Patella of pedipalp also with two parallel light dorsal lines. Trichobothria long and numerous, in two rows on all tibiae and metatarsi and in four rows on all tarsi. Claw-tufts heavy, concealing the claws entirely. Legs 4123.

	<i>Femur</i>	<i>Patella</i>	<i>Tibia</i>	<i>Metatarsus</i>	<i>Tarsus</i>	<i>Total</i>
I	14 5	7 8	11 0	11 0	6 5	50 8
II	13 8	7 0	9 2	11 0	6 5	47 5
III	11 5	6 5	8 0	11 0	6 5	43 5
IV	14 5	6 5	11 0	15 5	7 5	55 0

Width of first patella at the knee 2.552 mm. Tibial index 13.

Width of fourth patella at the knee 2.494 mm. Tibial index 14.

Spines.—First leg. Femur prolateral 1 at end, elsewhere 0. Patella 0. Tibia dorsal 0, prolateral 0-1-1, retrolateral 0, ventral 2-1r-1r (and the two apical hooks mentioned above). Metatarsus ventral 1 apical, elsewhere 0. Second leg same as first, except: Tibia ventral 1r-1r-2 and 2 spines in place of the two ventral hooks of the first tibia. Metatarsus prolateral 1-1, ventral 1-3, first spine at base, the other three apical, elsewhere 0. Third leg. Femur retrolateral 1 at end, elsewhere 0. Patella prolateral 1, elsewhere 0. Tibia dorsal 0, prolateral 1-1-1, retrolateral 0-1-1, ventral 1p-2-3. Metatarsus dorsal 0, prolateral 1-1-1-2, retrolateral 1-1-1, ventral 1p-1r-3. (There is therefore an apical verticellum formed by 6 spines). Fourth leg same as third, except: Patella 0. Tibia prolateral 0-1-0, retrolateral 1-1-1, ventral 0-2-3. Metatarsus very spinose and the spines irregularly arranged. There are apparently prolateral 0-1-1, retrolateral 0-1-1 and ventral 1r-2-1r-2-1r-2-4 spines. Palp. Tibia prolateral 1-1, retrolateral 0-1, ventral 1 in middle. Elsewhere 0. Copulatory apparatus shown in Pl. I, Fig. 16.

Color in alcohol very dark brown with almost white lines on legs and fringes at end of joints. Maxillæ and lip distinctly redder.

Sub-Order **Arachnomorphæ.**Family **Linyphiidae****Microneta aeronautica** sp. nov.

(Figures 17 to 20).

Four males of this species have been captured by Professor E. O. Essig on floating gossamer threads on November 9, 1928, on high Antioch Bridge at Antioch, California.

Type. Male.—Total length, 2.20 mm. *Carapace*, 1.02 mm. long; 0.80 mm. wide between second and third coxæ, 0.54 mm. wide in the region of the posterior row of eyes, which is 0.42 mm. long. Thoracic groove longitudinal. Head somewhat elevated and lateral eyes on a tubercle (Pl. I, Fig. 18). First row of eyes recurved, second row very slightly procurved, almost straight. AME distinctly, though not much smaller than ALE and closer to each other than to laterals. ALE of the same size as the eyes of the second row, which are equidistant. Laterals contiguous. Only AME diurnal. All eyes set in black. Quadrangle wider behind than in front in ratio 8.5 : 7, and as wide as long. Clypeus concave below AME, slightly convex toward edge, equal to $\frac{1}{3}$.5 of the length of the quadrangle.

Chelicerae parallel as far as the beginning of the margins. From here on they diverge and the margins are strongly oblique. When viewed from the side the chelicerae show a sudden constriction near end, and are now less than half as stout as in middle. Outer surface (dorsal) of chelicerae with well developed stridulatory ridges (Pl. I, Fig. 18). Promargin smooth, retromargin with 4 small teeth. Scopula wanting on both margins. Fang slender, normally curved. *Maxillæ* distinctly inclined over lip, slightly wider in front than at base. *Lip* twice as wide as long, strongly rebordered. *Sternum* almost triangular, longer than wide in ratio 24 : 21. Its anterior edge is nearly three times as wide as the lip, so that first coxæ are almost as far apart as second coxæ. Posteriorly the sternum is produced between the hind coxæ which are separated by almost their width. Legs 1423.

	<i>Femur</i>	<i>Pat. + Tibia</i>	<i>Metatarsus</i>	<i>Tarsus</i>	<i>Total</i>
I	1 24	1 52	1 24	0 76	4 76
II.	1 16	1 42	1 04	0 64	4 26
III	0 88	0 96	0 76	0 50	3 10
IV	1 20	1 36	1 12	0 60	4 28

Width of first patella at the knee 0.119 mm. Tibial Index 7.

Width of fourth patella at the knee 0.118 mm. Tibial Index 8.

Spines on all legs arranged in the same manner, as follows: Patella dorsal 0-1. Tibia dorsal 1-1, retrolateral 0-1. No spines elsewhere. No trichobothrium on fourth metatarsus. First tibia alone (without patella) longer than first metatarsus. *Palp* with short tibia at the end of which (Pl. I, Fig. 19) is a dorsal short process directed forward.

Cymbium large. Paracymbium sickle-shaped. Embolus (Pl. I, Fig. 20) spiral, long and fine. *Color* in alcohol: Carapace yellow with dark grey marginal band and dark grey median spot in front of thoracic groove. Legs yellow. Sternum yellow with dark grey marginal band. Abdomen light yellow with black pattern above (Pl. I, Fig. 17), yellow mottled with black below.

REMARKS ON THE GENUS CASEOLA EMERTON.

Emerton established his genus *Caseola* for two species, *herbicola* and *alticeps*, the former being the type of the genus. But *Caseola herbicola* has been found to be synonymous with *Maso frontatus* (Banks) and the genus *Caseola* becomes therefore a synonym of *Maso*. Through the courtesy of Mr. Emerton I was enabled to re-examine the types of both *herbicola* and *alticeps* for the purpose of determining the distribution of trichobothria and relative proportion of the segments of the first and fourth leg.

Caseola herbicola—Type, female: First leg, ratio of Tibia : Metatarsus : Tarsus = 14 : 11 : 5. Fourth leg 14 : 14 : 6.5. First and second tibia with two rows of ventral spines. Trichobothria: First leg, Tibia 1-1-1, Metatarsus 0. Fourth leg, Tibia 1-1-2-1, the first two very small. Metatarsus 1 long trichobothrium beyond middle.

Caseola alticeps—Type, female. Ratio of Tibia: Metatarsus: Tarsus, in First leg = 12 : 10 : 7, in fourth leg = 14 : 12 : 7. No true spines on legs except one ventral spine on each femur near distal end. Trichobothria: First leg, Tibia 1-2-1-1, Metatarsus 1 beyond middle. Fourth leg same as first. Carapace and sternum smooth, not reticulated. *Caseola alticeps* is evidently generically distinct from *Caseola herbicola* and may be provisionally placed in the genus *Araeonus* until the discovery of the male will make its generic affiliation clear.

Family **Thomisidæ**.**Philodromus setosus** sp. nov.

(Plate I, Fig. 21).

Total length 4.675 mm. Carapace 2.21 mm. long, 2.38 mm. wide. Both rows of eyes recurved, but first row much shorter than second and much stronger recurved. Eyes of first row equal in size. AME twice as far from each other as from ALE. Distance between AME is equal to $\frac{1}{2}$ of their diameter, that between AME and ALE to $\frac{1}{2}$ of the diameter of AME. Eyes of second row equidistant. PME smaller than the eyes of the first row, PL E larger than the eyes of the first row. Quadrangle slightly wider than long in ratio 12 : 11, wider behind than in front. Clypeus narrower than length of quadrangle in ratio 7 : 11. Legs 2413.

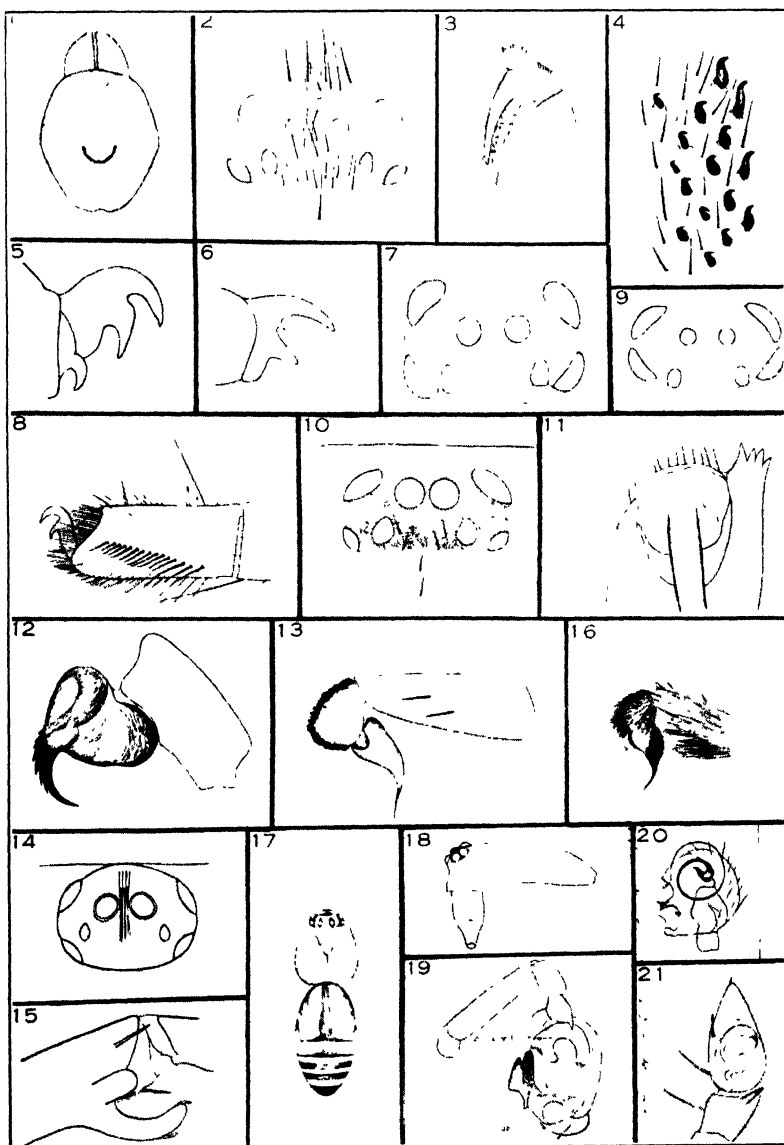
	<i>Femur</i>	<i>Pat + Tibia</i>	<i>Metatarsus</i>	<i>Tarsus</i>	<i>Total</i>
I	3 230	4 080	2 465	1 530	11 305
II	3 825	4 675	2 975	1 700	13 175
III	3 230	3 825	2 380	1 360	10 795
IV	3 570	4 165	2 890	1 445	12 070

A heavy scopula on all tarsi and metatarsi, except the fourth which are scopulate only at end. Spines: First leg, Femur dorsal 1-1-1, prolateral 1-1-1, retrolateral 1-1-1, ventral 0. Patella prolateral 1, elsewhere 0. Tibia 0-0-1, prolateral 1-1-1, retrolateral 1-1-1, ventral 2 2-2. Metatarsus dorsal 0, prolateral 1-1, retrolateral 0-1, ventral 2-2. Arrangement of spines on other legs the same, except on the fourth femora where we find dorsal 1-1-1, prolateral 0-1-1, retrolateral 0-1-1, and ventral 0 spines. Color in alcohol, above and below, buff with scattered brown spots. Abdomen with two narrow white bands converging to a point posteriorly. Palp as shown in Pl. I, Fig. 21. Tibial apophysis straight, Embolus short, curved. Seminal receptacle S-shaped.

One male captured on board S. S. Aconcagua sailing from Valparaiso.

EXPLANATION OF PLATE I

- Figs 1 to 9 *Pachylomerus carabivorus* Atkinson (a) Female from Georgia 1, Carapace, 2, Eyegroup, 3, Chelicera showing rastellum, margins and fang 4, Armature of retrolateral surface of second tibia, 5, Upper and third claw of left fourth leg, 6, Claw of pedipalp (b) Female from Virginia 7, Eyegroup (c) Female from unknown locality 8, Retrolateral view of fourth left tarsus showing comb and club-shaped hairs (d) Young from Virginia 9, Eyegroup
- Figs 10 to 12 *Myrmekiophila fluviatilis* (Hentz) Male 10, Eyegroup, 11, Right chelicera viewed from below, showing rastellum on a coneshaped protuberance and base of fang, 12, Left copulatory apparatus in retrolateral view
- Fig 13 *Eurypelma mgrxi* Simon Pedipalp of male
- Figs 14 to 16 *Cyrtopholis bartholomei* (Latreille) Male from Saint Thomas 14, Eyegroup, 15, Prolateral view of the distal end of the first left tibia, showing the two ventral hooks with their spines, 16, Copulatory apparatus of left pedipalp in retrolateral view
- Figs 17 to 20 *Microneta aeronautica* sp nov Male 17, Dorsal view, showing pattern, 18, Lateral view of carapace, showing lateral eye tubercle and stridulatory ridge, 19, Right pedipalp in retrolateral view, 20, Same pedipalp viewed from in front, showing spiral embolus
- Fig 21 *Phidromus setosus* sp nov Male Ventral view of pedipalp



HEIGHT AND SILKING AS FACTORS INFLUENCING EUROPEAN CORN BORER POPULATION

C. R. NEISWANDER AND L. L. HUBER,
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One of the factors of the environment that "causes" fluctuations in population of the European corn borer is the stage of development of the corn during the period of moth flight and larval feeding. For several years the experimental plots at Bono, Ohio, have shown a higher population on early varieties of a given planting date than on late ones, while succeeding planting dates have shown a significant reduction in the borer population of all varieties.

TABLE 1.
SHOWING MEAN POPULATION FOR SIX VARIETIES PLANTED ON
FIVE DATES, BONO, 1927.

PLANTING DATE	VARIETY					
	MEAN POPULATION IN TRIPPLICATE PLOTS					
	Wisconsin	Golden Glow	Medina Pride	Clarage	Leaming	Burr-Leaming
May 10	1102	885	859	910	686	509
May 20	740	606	579	533	504	421
May 30	419	217	225	228	108	91
June 5	168	106	129	95	77	60
June 10	36	25	41	29	14	16

The data in Table 1 show the population of six varieties planted on five different dates in 1927. The varieties are arranged in order of their length of growing season, Wisconsin No. 25 being the earliest. It will be noted that the early maturing varieties have the highest populations.

The significance of this record is indicated in Table 2, where the population of each variety is compared with every other variety. The magnitude of the difference in population between the earliest and latest variety is tremendous. On the other hand, there is no appreciable difference between some of the intermediate varieties such as Golden Glow, Medina Pride,

TABLE 2.

SHOWING SIGNIFICANCE OF DIFFERENCES IN POPULATION IN SIX VARIETIES PLANTED AT BONO, 1927.

Varieties		Odds that this Difference in Population is not Due to Chance	
Wisconsin	vs. Golden Glow	64.79	to 1
	Medina Pride.....	64.79	to 1
	Clarage.....	64.79	to 1
	Leaming.....	19,230.00	to 1
	Burr-Leaming.....	1,470,588,234.00	to 1
Golden Glow	vs. Medina Pride... ..	1	to 1
	Clarage.....	1	to 1
	Leaming... ..	37.46	to 1
	Burr-Leaming	19,230	to 1
Medina Pride	vs. Clarage	1	to 1
	Leaming	26 40	to 1
	Burr-Leaming.....	19,230	to 1
Clarage	vs. Leaming.....	22 26	to 1
	Burr-Leaming.....	1,350 35	to 1
Leaming	vs. Burr-Leaming.....	13.58	to 1

and Clarage. Relative to these three varieties, it is of importance to note that, as measured by mean silking date, there were but slight variations in their stage of maturity during the period of moth flight and larval establishment.

The coefficient of correlation between date of planting and population is -.83, the odds being 740 to 1 that the correlation

TABLE 3.

SHOWING SIGNIFICANCE OF DIFFERENCES IN POPULATION ACCORDING TO PLANTING DATES.

Planting Dates		Odds that the Difference in Population is not Due to Chance	
May 10 vs.	May 20.....	31.86	to 1
	May 30.....	Over 1,470,588,234	to 1
	June 6.....	"	"
	June 10.....	"	"
May 20 vs.	May 30.....	Over 1,470,588,234	to 1
	June 5.....	"	"
	June 10.....	"	"
May 30 vs.	June 5.....	1,470,588,234	to 1
	" 10.....	Over 1,470,588,234	to 1
June 5 vs.	June 10.....	Over 1,470,588,234	to 1

is significant. Reference to Table 1 will show that the variation in the population of the various planting dates is greater than for the varieties. The magnitude of the differences in populations when one planting date is compared with another is shown in Table 3.

Corn development, however, is the resultant of numerous factors, some of which are known and some unknown. Two of the factors which are known to have a significant influence on populations are height and date of silking. It is important

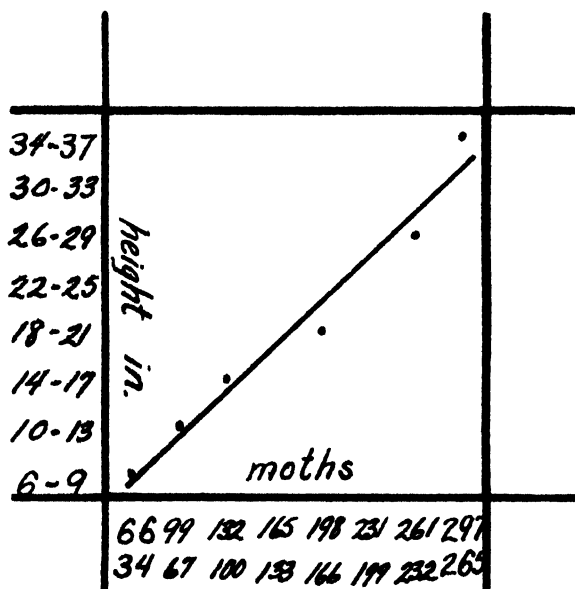


FIGURE 1.

to bear in mind that these two factors may work either together or independently. In the event they work together, as in the case of early and late planting dates, wide fluctuations in populations would occur, for under such conditions oviposition and establishment would be maximum in the former instance and minimum in the latter. In the discussion which follows it will be shown that corn borer population is fundamentally a result of either the number of eggs deposited, or the rate of larval establishment, or both and that the height and silking date of the corn are closely correlated with oviposition and establishment.

FACTORS INFLUENCING OVIPOSITION.

Height and Egg Deposition.

Moth flight for 1927 over the variety and date series of plantings indicated a close relationship between the height of the corn in the various series of plantings and the number of

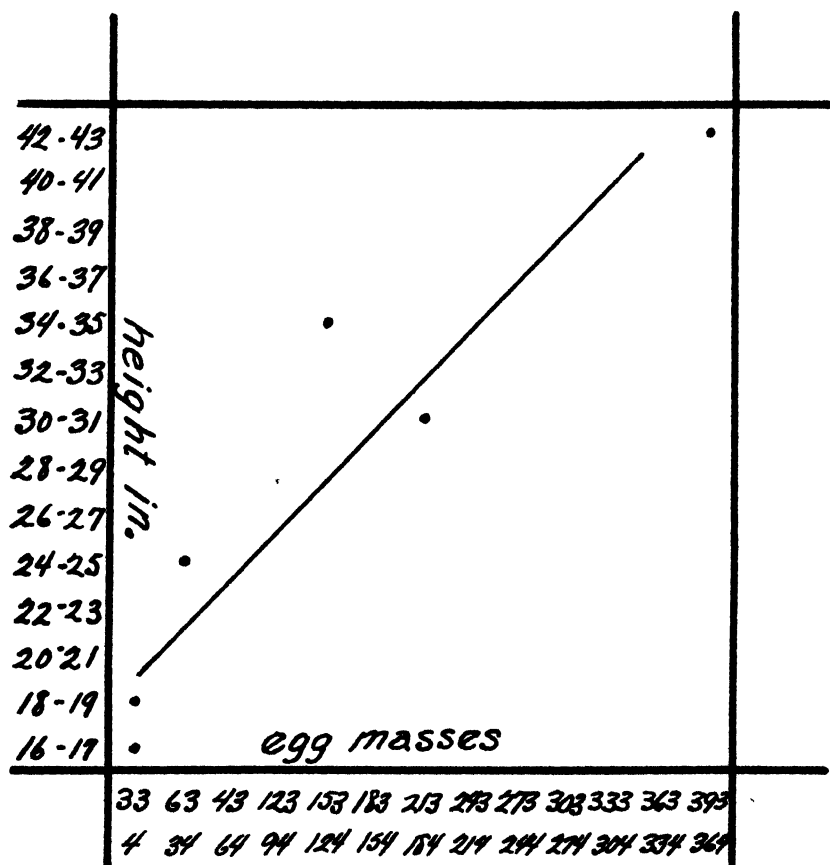


FIGURE 2.

moths seen flying above the respective series. From June 27 to July 12 a total of 967 moths were observed. The correlation between the number in flight and the corresponding height of these same plantings is .98 (Figure 1). The odds calculated from the formula $t = \frac{r}{\sqrt{1-r^2}} \times \sqrt{n'-2}$ as given by Fisher (1)

are 4991 to 1 that there is a significant correlation. For each inch reduction in height in these plantings there was a reduction of 8.8 moths as figured from the regression equation of moths on height using this correlation coefficient.

The above record, of course, does not throw light upon oviposition except in as far as it may be inferred that the

TABLE 4.
SHOWING WEEKLY HEIGHT RECORD AND OVIPOSITION IN FIELD PLOTS.
1927.

Variety	Average Height of Plants During Oviposition Season, Inches	No. Eggs Per Plant
Burr-Leaming (Normal) . . .	51	46
Wisconsin (Normal)	49	40
Wisconsin (Sub-normal)	43	26
Burr-Leaming (Sub-normal) . . .	33	8

1928.

Variety	Average Height of Plants, Inches						No. Eggs Per Plant
	Stalks examined	July 3	July 10	July 17	July 24	Season Average	
Burr-Leaming (Normal)	99	32	48	61	81	56	27
Clarage (Normal)	97	30	46	60	80	54	22
Wisconsin (Normal)	99	28	42	54	71	49	16
Clarage (Sub-normal)	97	25	38	49	69	45	14
Wisconsin (Sub-normal)	100	19	31	41	57	37	8
Burr-Leaming (Sub-normal)	99	16	27	39	55	34	5

moths would deposit eggs in the various local areas of the field in which they were observed. The writers have presented data (2) showing the actual egg deposition on two varieties of corn, Clarage and Golden Bantam, when planted on three different dates. When the average height of these varieties is plotted against egg masses a correlation coefficient of .97 is obtained, the odds being 3558 to 1 that this result is significant. (Figure 2). For each inch reduction in height of these plots there was a reduction of 14.5 in the number of egg masses deposited as figured from the regression equation of egg masses on height using this correlation coefficient.

In a former publication, (2) the writers presented data showing the relation between oviposition and plant height for two varieties of field corn, each occurring under two different growth conditions. In Table 4 it is shown that there was a marked decrease in egg deposition as the average height of plants decreased, irrespective of varieties. The correlation coefficient in this instance is .99, the odds being over 600 to 1 (Figure 3) that plant height and oviposition are correlated.

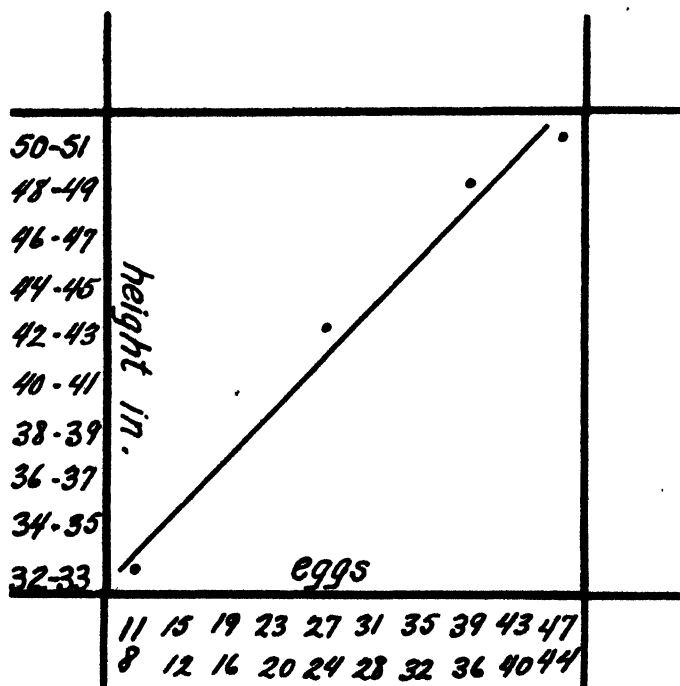


FIGURE 3.

In this case for each inch reduction in height there was a decrease of 1.9 in the number of eggs deposited.

The data for 1928 in Table 4, likewise show high correlation between egg deposition and height of plant, the correlation coefficient in this instance being .97 with odds of 7142 to 1 that this correlation is significant. (Figure 4). For each inch decrease in height there was a reduction of .9 in the number of eggs per plant as calculated from the regression equation of eggs on height using this correlation coefficient. In each of

the two years it was found that the greater the average height of corn in the plot the more eggs were deposited. The records seem especially significant in that the one variety that had both maximum and minimum average heights also had maximum and minimum average egg deposition. In like manner all other plots were in the same relative position in the attractiveness rating as in the height rating.

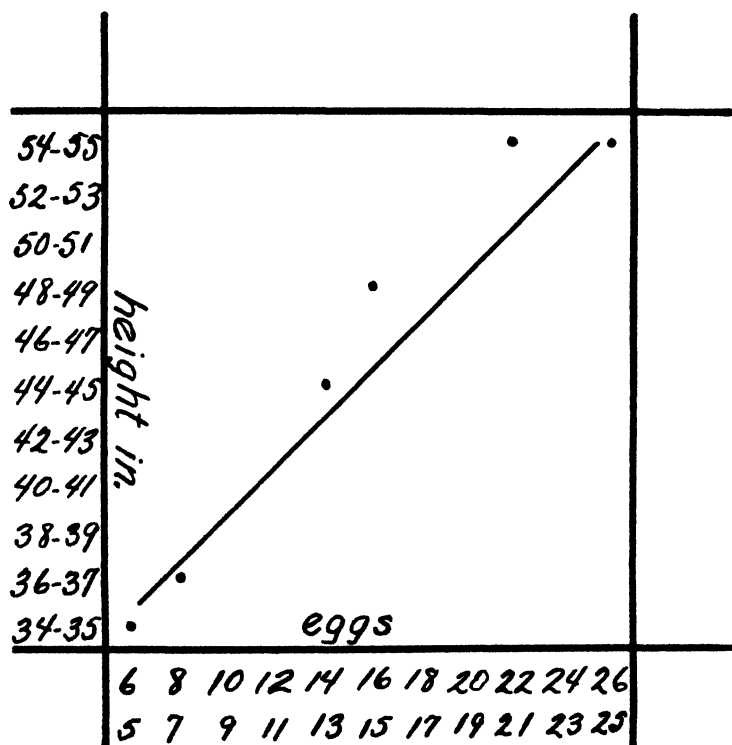


FIGURE 4.

It may be seen that the records for the two years, 1927 and 1928, are closely analogous, there being not only a steady decrease in oviposition as the height decreases, for each year, but also a slight variation in the percent decrease in egg deposition per inch decrease in height for the two years. In other words, not only is the attractiveness of different heights consistently and uniformly variable for each year but also the ratio of variability is practically equivalent for the two years.

It is now of interest to inquire into the relationship between number of eggs per plant and the height of individual plants within a single plot as contrasted with the high correlation

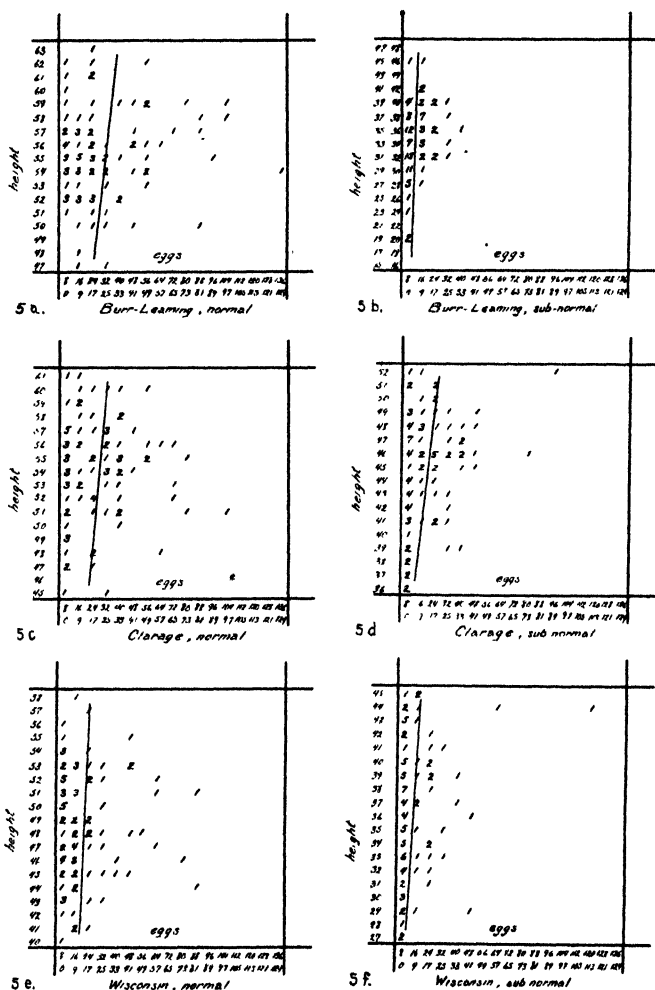


FIGURE 5.

found between number of eggs by plots and the average height of plots. Individual records on development and oviposition were kept on all plants within the different plots studied in 1928. These records throw light on whether or not the moths oviposit on the individual plants of the plot at random or

whether in this instance they also respond with respect to plant height. Reference to Figure 5, a to f, and Table 8 will indicate at once that there is only a slight correlation between oviposition and the height of individual plants within a plot. The straight lines, Figure 5, a to f, graphically illustrate the degree of correlation. Although there is a slightly greater number of eggs deposited on the larger plants, it would appear that there is no important tendency for the moth to select them as compared to the tendency shown in the data for the plots as units, since random oviposition would result in a greater number of eggs on the larger plants.

TABLE 5.

SHOWING COEFFICIENTS OF CORRELATION BETWEEN HEIGHT OF INDIVIDUAL PLANTS AND NUMBER OF EGGS.

Variety	Condition	No. of Plants	CORRELATION	
			Value	P. E.
Burr-Leaming	Normal . .	99	.1075	.066
Burr-Leaming	Sub-normal .	100	.2652	.062
Clarage	Normal .	97	.1307	.066
Clarage	Sub-normal .	99	.2307	.064
Wisconsin	Normal . .	96	-.0375	.069
Wisconsin	Sub-normal .	99	.1211	.066

Silking and Egg Deposition.

Having shown the correlation between height of plant and egg deposition it is now in order to discuss the relationship between silking and oviposition. Data secured on the Bono varietal and date of planting plots in 1927, as previously described, in which six varieties were planted in triplicate on six different dates, showed a correlation of $-.91$ between silking and egg deposition, the odds being 615 to 1 that the correlation is significant. The correlation between moth flight and silking on these same plots is $-.97$, the odds being 4055 to 1 that the result is significant. This high correlation might lead to the conclusion that date of silking as such, greatly influences the moths and consequently the number of eggs deposited. However, in this instance silking includes more than stage of development as such. Where the six varieties are made the equivalent of one variety on the successive dates of planting a high correlation between silking and eggs can be expected for the correlation between silking and height is high.

Just what it is that attracts the moths to the corn plants is not known. It is not even definitely known by what sense the insects respond to the stimulating attractant. For this reason it is impossible to say that height of plant is the determining agent. It is perfectly fair to state, however, that in so far as the foregoing records are concerned, attractiveness correlates directly with height of plant in all cases. Therefore, the attractive agent, if not height itself, certainly must be directly proportional to height during the oviposition period.

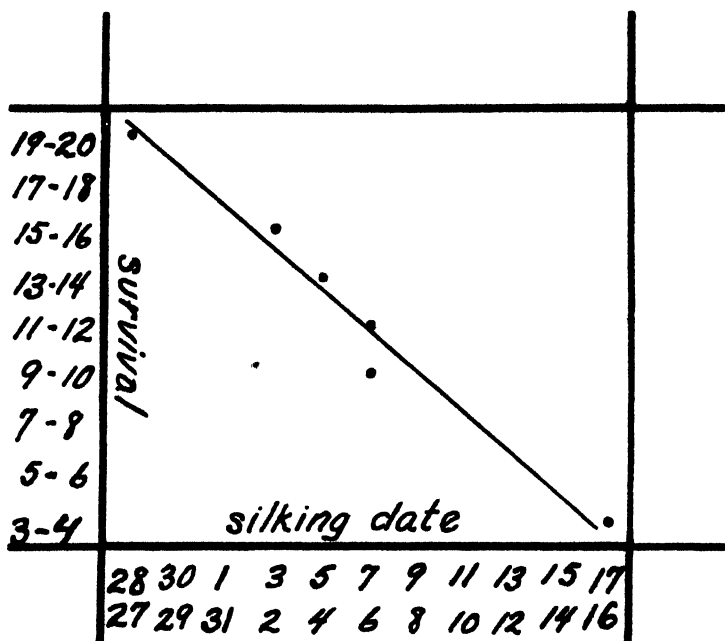


FIGURE 8.

FACTORS INFLUENCING ESTABLISHMENT.

Early vs. Late Planting.

The relationship of the actual number of eggs and the survival rate of larvæ as factors influencing final population will now be considered. It is a demonstrated fact that moths deposit more eggs on early than on late corn and on high than low growing corn (2). Moreover, it is accepted that early corn generally carries a higher borer population than late corn. Is this difference in population due to a difference in the number

of eggs only or does earliness or lateness of corn have an influence on the chances of survival?

Results of certain studies in 1925 indicated that differences in populations were not wholly due to variations in number of eggs. As a consequence of this supposition Mr. E. G. Kelsheimer in 1926 artificially infested each of 18 stalks of corn, 9 planted on May 10 and 9 planted on June 10. This corn was all of the same variety planted in adjoining plots. The number of eggs placed on the corn and the percent of larval recoveries are given in Table 6.

TABLE 6.

SHOWING LARVAL SURVIVAL ON CORN PLANTED MAY 10 AND JUNE 10, 1926.

Time	PLANTED MAY 10		PLANTED JUNE 10	
	Eggs Deposited No.	Larvæ Recovered %	Eggs Deposited No.	Larvæ Recovered %
July 10	194	13.9	194	4.1
12.	194	5.1	194	3.1
14.	176	6.8	176	0
14.	200	12.0	200	5.5
16.	150	12.6	150	12.0
19.	190	7.9	190	5.3
19.	196	8.7	182	8.8
21.	247	6.1	228	7.9
22.	168	18.4	168	4.8
Average		10.16		5.72
Difference				4.44

According to the formula $t = \frac{\bar{x} - \bar{x}^1}{s} \sqrt{\frac{(n_1 + 1)(n_2 + 1)}{n^1 + n^2 + 2}}$ by Fisher (1) the odds are 68.0 to 1 that the foregoing difference, 4.4 percent, is significant.

In 1928 a series of plots consisting of different varieties of dent, sweet, and flint corn were studied for survival rates under two widely different dates of planting. As far as was known all environmental conditions except the condition of growth resulting from the differences in planting date were kept constant for each variety. The varieties, however, were grown in different localities, hence cannot be compared.

Each plot, Table 7, consisted of 36 plants arranged in a rectangle. By means of moths confined in cages, oviposition

was forced on all of the hills of each plot, corresponding parts of each plot being subjected to oviposition at the same time in order to obtain comparable treatments. The natural deposition of the eggs on the plants by the moths themselves is contrasted here to the artificial deposition described in the experiment above. It will be seen that the final results are practically the same.

TABLE 7.

SHOWING SURVIVAL ON EARLY AND LATE PLANTINGS, OAK HARBOR, 1928.

Variety	Plants in plot	Eggs per Plot		Larvæ Recovered per Plot		Percent Survival		Percent Reduction in Survival
		May 10	June 10	May 10	June 10	May 10	June 10	
Golden Bantam. . .	36	8007	7322	1289	636	16.10	8.69	46.02
S. Evergreen.....	36	8093	4052	753	193	9.32	4.76	48.93
Leaming.	36	11915	8980	1578	803	13.24	8.94	32.48
Long. Flint.....	36	8108	8697	909	285	11.21	3.27	70.83
Average.....	.	.	...		.	.		49.565

The data in Table 7*show clearly that there was a difference in survival on the May 10 and June 10 corn, the average reduction being 50.43 percent. According to the formula

$t = \frac{\bar{x} \sqrt{n^1}}{s}$ the odds were 129 to 1 that this difference in survival is significant.

Early vs. Late Developing.

(Normal Against Subnormal Corn).

It has been shown elsewhere (2) that there was a considerable difference in the larval survival on normally and subnormally growing Wisconsin and Burr-Leaming varieties in 1927. On the subnormal Wisconsin 44.25 percent as many borers survived from a given number of eggs as on the normal, while on the subnormal Burr-Leaming the survival was 53.67 percent as great as on the normal plot. The average survival on the subnormal plots was 48.96 percent of the normal. These are significant differences. While no record was kept on the date of silking of the different plots it is known that the vigorous series silked several days earlier than the non-vigorous.

In 1928 similar records were taken except that two development rates of Clarage were included and silking date records of all plants were taken on each plot. It may be noted that in case of every variety listed in Table 8 there was a heavier egg deposition in the vigorous than in the subnormal series. Despite the possible influence of competition there was a higher percent survival on the vigorous than on the subnormal. The subnormal plots, as an average, silked 6.7 days later than the normal and had 36.70 percent lower larval survival, or a reduction of 5.5 percent in larval survival for each day's delay in

TABLE 8.
SHOWING COMPARATIVE SURVIVAL ON CORN WITH TWO
DEVELOPMENT RATES, 1928.

	Eggs per Plant	Popula- per Plant	Percent Survival	Average Silking Date	Decrease in Survival in Percent of Normal Plot	Percent Decrease in Population
Wisconsin No. 25.						
Vigorous Plot	16.17	3 21	19 9	July 27.5	19 10	58 56
Subnormal plot.	8.28	1 33	16 1	Aug. 2.1		
Clarage.						
Vigorous plot.	22.12	3 20	14 5	Aug. 4.7	22 07	49 38
Subnormal plot.	14 28	1 62	11 3	Aug. 7.9		
Burr-Leaming.						
Vigorous plot.	26.61	2 75	10 3	Aug. 6.2	68 93	93 82
Subnormal plot.	5 24	17	3 2	Aug. 17.6		
Average.					36 7	

date of silking even within the variety. These data show that the average survival on the subnormal plots was 63.30 percent as great as on the normal, the odds being 65.7 to 1 that this result is significant.

Short Season Varieties vs. Long Season Varieties.

Evidence presented in Tables 6 and 7 warrant the deduction that larval survival was lower on late than on early corn and, therefore, contributed to reduction in the population of the late corn. It has been pointed out previously that fundamentally the difference in development of a single variety planted on two different dates may be equivalent to the difference obtaining in two different varieties planted on the same date. It is to be expected, therefore, that survival will vary according to varieties.

It has been shown also (2) that a higher percent survival occurred on Wisconsin No. 25, an early maturing variety, than on Burr-Leaming, a late maturing variety. The comparison of varieties in 1928 gave the same result but was made increasingly significant by the addition of another variety and by the fact that complete silking date records were taken. The record for 1928 is given in Table 9. The percent survivals are arranged in order of the silking date of the varieties.

In this record (Table 9) it may be seen that in every case except one there was a regression of percent survival with

TABLE 9.
SHOWING RELATION OF PERCENT SURVIVAL WITH DATE OF SILKING, 1928.

Variety	Silking	Percent Survival	Delay in Silking Date as Compared With Earliest	Decrease in Survival as Compared With Max.	
				Actual	Percent
			Days		
Wisconsin No. 25 N	July 27 5	19 9	0 0	0.0	
Wisconsin No. 25 SN	Aug. 2 1	16 1	5.6	3 8	19 1
Clarage N	Aug. 4 7	14 5	8.2	5 4	27 1
Burr-Leaming N	Aug. 6 2	10 3	9 7	9 6	43.2
Clarage SN	Aug. 7 9	11 3	11 4	8.6	48 2
Burr-Leaming SN	Aug. 17 6	3.2	21 1	16 7	83 9
Average			11.2		44 3
Average percent decrease in survival per day delay in silking			1 0		4 0

earliness of silking. The coefficient of correlation is .98, the odds being 4761 to 1 that the correlation is significant. Figure 6 shows the regression of larval survival on date of silking calculated from this coefficient of correlation.

Although the correlation between survival and stage of maturity was high on whole plots, an analysis of the data with respect to the relation of silking and population of individual plants of the plots showed only a small correlation. When these correlation values (Table 10) are transformed to Z according to the method given by Fisher (1) and then retransformed, the value of the generalized correlation coefficient is found to be $-.18 \pm .03$. When this is compared with the correlation coefficient of .98 obtained when the correlation is calculated for

the whole plots it seems evident that other factors are nullifying the influence of maturity of the corn on survival. It is probable that one of these factors, possibly the major one, is the migration of larvæ from early maturing stalks to late ones within the same hill or between hills. Such migration would effect a general leveling of population.

SUMMARY.

The question naturally arises as to why delay in maturity as indicated by silking should reduce the survival rate of corn borer larvæ. No definite answer can be given to the

TABLE 10

SHOWING COEFFICIENT OF CORRELATION BETWEEN SILKING AND POPULATION OF INDIVIDUAL PLANTS.

Variety	PLANTS		CORRELATION		
	Kind	No.	Value	P. E.	Z Value
Burr-Leaming . .	Normal . .	99	— .3665	.058	— 384
	Subnormal	100	— .2003	.065	— .203
Clarage	Normal . .	97	.0636	.067	.064
	Subnormal	99	— .2166	.065	— .220
Wisconsin. . . .	Normal	96	.0485	.068	— .049
	Subnormal	99	.1788	.065	— .181

question at present. However, in connection with a seasonal history study made on various varieties of corn in 1927 and 1928, it was found that the greatest difference in mortality occurred at the time the larvæ were becoming established upon the corn plant or were starting to feed. Data secured in 1928 showed that by the end of the two-week period including July 16-31 there already had been a mortality of a little over 79 percent in Burr-Leaming and Clarage, while in Wisconsin it was under 70 percent. The average mortality for the season, i.e. from July 16 to September 12, was 79, 86, and 88 percent, respectively, for Wisconsin, Clarage, and Burr-Leaming.

An analysis of the location of the larvæ in the different varieties during this period shows that on July 23-25, 45 percent of the larvæ in Wisconsin, No. 25 were feeding on or amid the tassel. In Burr-Leaming there were only 8 percent amid the

tassel, while a correspondingly large number were amid the rolled leaves of the plant. In other respects there was not a great difference in the location of the borers in the two varieties. A week later, July 30—August 1, there were 5.6 percent in the tassel of Wisconsin to 12.4 percent in Burr-Leaming, while Wisconsin already had 28 percent within the plant stem to 5 percent in Burr-Leaming.

It would appear that as far as the evidence presented herein is concerned the resistance to the attack of the corn borer rests upon two factors, (a) resistance to oviposition and (b) resistance to survival. The later corn, or that which is smaller during moth flight, exhibits a greater resistance to oviposition than does that which is earlier and larger at the same period. Conversely, that which is larger is more attractive. Resistance to survival varies inversely with the silking date of the host, whether variety, planting date, or merely rate of development within a given variety or planting date is concerned.

The difference in place of feeding is correlated with the fact that in Wisconsin the tassels appear earlier than in Burr-Leaming and also that the tassels open up sooner in Wisconsin, thus forcing the borers inside the stem at an earlier date. Inasmuch as the mortality for the remaining larval period was practically equivalent in the two varieties it seems logical to assume that this specific difference in the development of the varieties was responsible for the difference in the survival rates. It would appear rather certain that the time of tasseling has a very definite relationship to the development of young larvæ and that the early tasseling hosts are more perfectly timed to the early larval growth and accordingly larger percentages of larvæ are able to become established upon them.

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DESCRIPTIONS OF FIVE NEW NORTH AMERICAN ANTS, WITH BIOLOGICAL NOTES.*

M. R. SMITH,
A. & M. College, Mississippi.

Recently there have come to my attention five new ants which seem worthy of description. Among them is a new Ponerine ant and four new Myrmicine ants, all of which are native to Mississippi except the species *Pogonomyrmex californicus barnesi*, an Arizona ant. Included with these descriptions is that of the heretofore undescribed male of *Ponera opaciceps* Mayr. Where possible, comments have been made on the biology of these ants.

I wish to acknowledge here my indebtedness to Dr. W. M. Wheeler, of Harvard University, for his opinion concerning the taxonomical status of these ants.

PONERINÆ.

Euponera (*Trachymesopus*) *gilva harnedi* subsp. nov.

Worker. Length: 2.9-3.1 mm.

Head, excluding mandibles, slightly longer than broad, but not quite so broad as with typical specimens of the species. Posterior border not strongly but yet clearly emarginate, sides faintly convex, converging anteriorly, thus causing the width of the head in the region of the mouth to be narrower than the width of the head measured through the posterior angles. Eyes very small and indistinct, with only 8-10 ommatidia; placed at a distance from the mandibles equivalent to at least two and a half times their greatest diameter. Mandibles well developed, triangular, moderately convex, with 6-8 distinct teeth. Clypeus short, strongly carinate, medianly, especially near the posterior border. Frontal carinæ flattened, each forming a distinct lobe which covers most of the antennal insertion; between these and extending posteriorly is a narrow, impressed, frontal groove which reaches almost to the vertex of the head. Antennal scapes robust, lacking approximately twice their greatest diameter from reaching the posterior border of the head; funiculi gradually becoming broader distally, all segments except the first and last distinctly broader than long.

Pronotum narrower than the head, long as broad, flattened above and with broadly rounded humeri. Pro-mesonotal and meso-epinotal sutures distinct. Epinotum not so long or as wide as the pronotum and

*A contribution from the Mississippi Agricultural Experiment Station.

mesonotum together, laterally compressed at the base, but becoming wider posteriorly; in lateral profile its dorsal outline is almost straight, horizontal, and lower than the mesonotum, and passes into the declivity in a rather rounded angle. Petiole slightly broader than the posterior part of the epinotum, with broadly rounded dorsal surface, and prominent, rounded, plate-like tooth below. Gaster oval, truncate at base, widest at posterior border of second segment, apex with a well developed sting.

Mandibles smooth, shining, with a few sparse piligerous punctures which are largest near the apical borders, at the base with several indistinct striae. Head opaque, finely and densely punctate, with a velvety effect. Thorax, petiole, gaster and legs less opaque, slightly shining, with very fine scattered punctures.

Hairs and pubescence golden yellow. Pubescence fine, dense, and closely appressed on the head, less so on the thorax, on the abdomen longer, coarser and less appressed. Hairs erect, moderately long, scattered over the body but most evident on the gaster.

Ferruginous, appendages scarcely paler, mandibles darker.

Described from numerous workers, the cotypes of which are in my collection, the collection of the Department of Entomology of the Mississippi A. & M. College and the collection of Dr. W. M. Wheeler.

The ants of this interesting subspecies were taken from beneath the bark of a moist, rotting pine log in a woodland strip at Columbus, Mississippi. The ants were very slow of movement and in some cases feigned death at the point of capture. The workers bore such a close resemblance to the workers of *Proceratium* or *Sysphincta* in size, color and movements, that I did not recognize them as something different until I reached the laboratory. It is interesting to remark here that from the same log came also a new Fulgorid belonging to the genus *Epiptera*, but which was apparently not associated with these ants nor the ants *Aphanogaster texana* var. *carolinensis* Wheeler.

In regard to the rarity of *E. gilva* (Roger), Wheeler and Gaige have written in *Psyche*, vol. 27, p. 69 (1920) as follows: "In 1863 Julius Roger described, among other North American Formicidæ, *Ponera gilva* and *Discothyrea testacea*, two species which the senior author has vainly sought for the past twenty years, both in the field and in numerous collections sent him for identification. 'Nordamerika' was the only locality appended to the descriptions, and as the other species of the two genera are tropical or subtropical, it was natural to infer

that Roger's types were taken somewhere in Mexico. The *Discothyrea* is still to be rediscovered, but recently the junior author succeeded in taking four workers of *gilva* in northwestern Tennessee." The authors also state, "but *gilva* must either be extremely local or its female would have turned up in some of the many collections made since 1863. It would seem to be in fact, an ancient relic on the verge of extinction."

The workers of this new subspecies differ in a number of respects from that of the typical *gilva* described by Wheeler and Gaige in the issue of *Psyche* mentioned above. The differences are as follows: (1) the body is somewhat smaller and less robust; (2) the head narrower, and with shorter antennal scapes; (3) the eyes smaller; (4) the sculpturing finer and more shining; (5) the pilosity less coarse, and also less abundant.

I take pleasure in naming this ant for Professor R. W. Harned, who has kindly aided me in every possible way in my studies on North American ants and especially those ants native to Mississippi.

***Ponera opaciceps* Mayr**

Male. (Alate)—Length: 2.4–2.6 mm.

Head, excluding the mandibles, scarcely longer than broad, with rounded posterior angles. Eyes large, oval, convex. Ocelli arranged in the form of a triangle, the distance between one of the lateral ocelli and that of the median ocellus less than the distance between the two lateral ocelli. Cheeks extremely narrow. Mandibles small, short, edentate. Clypeus strongly convex, the anterior border without a median emargination. Antennæ 12-segmented, filiform; scapes short and slender, not longer than the second funicular segment. Thorax short, robust. Mesonotum with distinct parapsidal sutures, but without Mayrian furrows. Wings pale, with faint yellowish veins. Anterior wings, each with a closed radial cell, two closed cubital cells and a closed discoidal cell. Legs moderately long and slender, the tibia of each with a distinct spur at its distal end. Petiole viewed in lateral profile broad at the base and perceptibly narrowing dorsally; from behind, the superior border of the petiole is rounded and entire. Gaster from above subelliptical, with a distinct constriction between the first and second gastric segments, the apex with prominently protruding genital appendages.

Subopaque; body finely shagreened, the shagreening covered by a dense, much appressed yellowish pile. Hairs yellowish, rather short, sparse, found on the mandibles, clypeus, top of head, coxæ of the legs, top of the petiole and apex of the gaster.

Black; mouth parts, appendages, wing insertions, and apex of the gaster lighter, or pale yellow.

This description is based on 12 alate males which were taken by Mr. J. P. Kislanko on December 15, 1928, from a colony nesting in a partly decayed pine stump at Ocean Springs, Mississippi. The cotypes are in my collection and the collection of the Department of Entomology of the Mississippi A. & M. College.

Ponera opaciceps ranges throughout the southern states and as far south as Mexico and Brazil. The worker of this species bears a close resemblance to the worker of *Ponera coarctata* subsp. *pennsylvanica* Buckley, but can be distinguished from the latter by its shorter, more robust head and by the finer punctation of the head. *Ponera opaciceps* is a southern form, whereas *P. pennsylvanica* is more northern in its distribution.

MYRMICINÆ

***Pogonomyrmex californicus barnesi* subsp. nov.**

This form seems to be intermediate between that of the typical *californicus* and its subspecies *maricopa*, but is perhaps nearer the latter. The worker of *barnesi*, however, resembles to some extent the worker of *maricopa* not only in size (6-7.5 mm.), but also in its subopaque appearance.

It differs from the worker of *maricopa* though in many respects, namely: (1) the node of the petiole is decidedly higher and more pointed above and with a rather abruptly sloping or steep posterior slope, and the pedicel bears below a distinct antero-ventral tooth; (2) the rugæ of the head and the thorax are much more pronounced and have very distinct interrugal punctures, and the petiole and post petiole are more coarsely shagreened; (3) the head, thorax, petiole and post petiole are much less shining than in the worker of *maricopa* and therefore practically opaque; (4) the color is a darker, more ferruginous red.

I am able to distinguish this form very readily from its nearest allies, *californica* and *maricopa* in that the workers of *barnesi* are more heavily sculptured and therefore more opaque, are darker in color, and possess a petiole of a very characteristic shape as described above.

This new subspecies is described from 8 specimens, all workers, which were taken by Mr. O. L. Barnes in Maricopa county, Arizona about twenty miles northwest of Phoenix.

Cotypes are in my collection and in the collection of the Department of Entomology of the Mississippi A. & M. College.

I take pleasure in naming it for Mr. Barnes who has kindly sent me a number of Arizona ants for identification.

***Leptothorax wheeleri* sp. nov.**

Worker.—Length: 2.2–2.9 mm.

Head, rather large, subrectangular, excluding the mandibles, slightly longer than broad, with practically straight posterior border, rounded posterior angles and feebly convex, almost straight, subparallel sides. Eyes moderately large, oval, convex, placed at a distance from the mandibles equivalent to or slightly surpassing their greatest diameter. Mandibles with 5 distinct teeth. Clypeus convex, with rounded anterior border, and a rounded posterior border extending for some

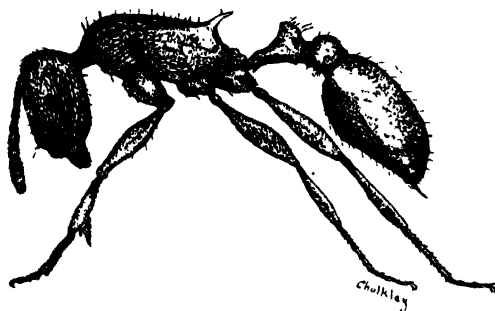


Fig 1. Worker of *Leptothorax wheeleri*.

distance between the frontal carinae. Frontal area obsolete. Antennae 11-segmented; scapes fairly robust not attaining the posterior angles of the head, first segment of the funiculi almost as long as the next three taken together, the distal segment longer than the two preceding segments taken together. Thorax robust, narrower than the head, anteriorly with rounded, yet distinct humeral angles; dorsum convex, sides not laterally compressed as with *fortinodis* and related species. Epinotal spines rather robust, long and curved, slowly narrowing to their apices which are directed upward, backward, and outward. Petiole viewed in lateral profile, not strikingly larger than the postpetiole, with feebly concave anterior and faintly convex or somewhat flattened dorsal surface, below with a distinct ventral tooth. Postpetiolar node strongly convex dorsally. Gaster viewed from above oval, truncate at base, with distinct humeral angles, apex with a sting. Legs stout, with incrassated femora.

Head, thorax, petiole, postpetiole and antennae opaque. Mandibles longitudinally striated. Clypeus coarsely, longitudinally rugulose. Head, thorax, and petiole rather coarsely rugulose-recticulate, with the interspaces finely punctate; on the head and thorax the rugulae are

decidedly longitudinal. Postpetiole finely punctate. Gaster smooth and shining, the legs less so.

Hairs light yellowish or grayish, short and rather abundant, erect on the head, thorax, epinotal spines, petiole, postpetiole and gaster.

Color, light to dark ferruginous red; gaster except the posterior borders of the segments and legs slightly paler. Mandibular teeth black. Antennæ somewhat infuscated, especially the funiculi.

Female (dealated).—Length: 3.9–4.2 mm.

Like the worker in coloration except that the ocelli, the meso-parapteral furrows, the wing insertions, the posterior edge of the scutellum, the metanotum, and a rather broad band at the distal end of the first gastric segment and a fainter band at the tip of the second and third gastric segments are infuscated.

Sculpturing similar to that of the worker, but coarser, especially on the thorax. Epinotal spines not as proportionally large as with the worker, but shorter and blunter, the intraspinal spaces greater than the length of either epinotal spine. The petiolar node of the female is decidedly more convex dorsally and has a sharper more abrupt posterior slope than that of the worker.

Pilosity and pubescence not noticeably different from that of the worker.

Described from 5 females and numerous workers, all of which were collected at A. & M. College, Mississippi. Cotypes of the females and workers are in my collection and the collection of the Department of Entomology of the Mississippi A. & M. College. Worker cotypes only are in the collection of Dr. W. M. Wheeler.

This species is very closely allied to *fortinodis*, *schaumi*, and *bradleyi*. Like these species, the workers and female have 11-segmented antennæ. The worker differs from that of *fortinodis* and *schaumi* in several respects, the most striking of which are: (1) that it has much longer and larger epinotal spines; (2) that the thorax is not compressed laterally and dorsally as with the two species just mentioned; (3) that the sculpturing is much coarser. From the worker of *bradleyi* it differs in the shape of the thorax and petiole, and also in several other characters.

I take pleasure in naming this species for Dr. W. M. Wheeler of Harvard University, the world's foremost formicologist, and to whom I am greatly indebted for considerable aid in my work on the ants of North America.

This large and beautiful, ferruginous-red species of ant is rather common in this vicinity. It was first collected in 1921

and erroneously referred to *Leptothorax schaumii*. (See Ent. News. Vol. 35, p. 50, 1924).

One colony was found nesting in an oak tree, apparently in the hardwood where the ants could be seen entering and leaving by small holes in the wood which I believe to have been made by some small boring beetle. March 20, 1922 I found a colony nesting in a niche in a dead, but fallen cottonwood tree. In this colony were 2 dealated females, 31 workers and a number of larvæ, but no other immature forms. April 25, 1928 another colony was found nesting in a cavity beneath the bark of a well rotted pine stump. In this nest were found 3 dealated females, 40 workers, and numerous larvæ. When the nest was disturbed the workers made frantic efforts to conceal themselves by crawling in small crevices, etc. The ants have also been taken in similar habitats at Adaton, Mississippi. Nothing is known concerning their feeding habits.

***Leptothorax* (D.) *pergandei flavus* subsp. nov.**

Worker.—Length: 2.6–2.8 mm.

Head subrectangular, excluding mandibles, longer than broad, posterior border straight, posterior angles rounded, sides moderately convex, subparallel in appearance. Eves rather large, oval, convex, placed at a distance from the mandibles equivalent to their greatest diameter. Mandibles with 5 distinct teeth. Clypeus moderately convex, broadly rounded in front and extending some distance posteriorly between the frontal carinæ. Frontal area obsolete. Antennæ 12-segmented; scapes surpassing the posterior angles of the head; club 3-segmented, the distal segment longer than the two preceding segments taken together. Thorax robust, viewed in lateral profile the dorsum of the prothorax and mesothorax form a rather long, well developed arch, which terminates at the deep and broad constriction between the meso-epinotum. Epinotal spines moderately large and robust, rather blunt, directed upward and outward. Legs with incrassated femora. Petiole viewed in lateral profile with well developed, rather strongly convex node and with a distinct anteroventral tooth beneath; postpetiole considerably larger than the petiole. Viewed from behind the superior border of the petiole is straight or rounded and without an emargination, postpetiole much broader than long and easily one and a half times as broad as the petiole. Gaster oval, truncate at base, and with well developed humeral angles, apex with a sting.

Mandibles longitudinally striated. Clypeus smooth, except for a median carina on its anterior border and longitudinal rugulæ on its lateral border. Head, with the exception of the longitudinal rugulæ around the base of the antennæ and on the cheeks, prothorax, dorsum of mesothorax and epinotum, petiole, postpetiole and gaster, smooth

and shining. Neck opaque, delicately rugulose-punctate; mesoepinotal constriction, and the pleuræ of the mesothorax, metathorax and epinotum, rugulose-reticulate.

Hairs white, coarse, long and abundant, erect on all parts of the body except the appendages; almost absent from the pleuræ of the thorax.

Yellow to yellowish brown; mandibular teeth black, head, antennæ, dorsum of mesothorax, legs, and posterior border of the gastric segments infuscated. The color of the body and the amount of infuscation is highly variable with different individuals.

Female (dealated).—Length: 3.6 mm.

As a whole very similar to the worker but differing to some extent in sculpture, color, shape and size of epinotal spines, and several other characters. The sculpturing is similar to that of the worker except that it is coarser; the rugulose-reticulate sculpturing is missing from the mesopleuræ and there are distinct longitudinal rugulæ between the mesonotum and the scutellum. Ground color of the body deep reddish brown; wing insertions, posterior edge of scutellum, metanotum, and posterior borders of gastric segments deeply infuscated. Epinotal spines small, blunt and tuberculate. Petiole viewed in lateral profile not as robust, convex, or as thick antero-posteriorly as with the worker; viewed from behind subrectangular, with straight or very feebly emarginate superior border.

This new subspecies has been described from 21 workers and a dealated queen which were taken from a rotting tree branch lying on the ground at Adaton, Mississippi. Cotypes of the workers are in the collection of the Department of Entomology of the Mississippi A. & M. College, my collection, and the collection of Dr. W. M. Wheeler. The female is in my collection.

The worker of this large, yellow form is closely allied to the worker of *pergandei* as is indicated by its 12-segmented antennæ, the strong constriction between the meso-epinotum, its abundant, coarse pilosity, etc. From the worker of this species it differs however in the following respects, namely: (1) its larger size; (2) different color (yellow); (3) the less acute meso-epinotal constriction; (4) the longer, blunter and stouter epinotal spines; (5) the much larger and more convex petiole, and the distinctly broader postpetiole; (6) and lastly, in its longer, coarser, and more uneven pilosity.

I have named this new subspecies *flavus* because this is the typical ground color of the ant. Cotype specimens show considerable variation in the amount of infuscation on the body, and specimens from other nests show the color of the ant

to be highly variable, yet in spite of all this, the yellow ground color dominates—hence I have named the ant accordingly.

The ants are common at Adaton, Mississippi where they are found nesting in crevices just beneath the bark of pine stumps, near where the soil touches the stumps. Colonies appear to range in size from 50 specimens to 175 to 200 specimens. So far, only one queen has been found in a nest, though others may have been in the nest, but escaped observation. The food habits of this species are unknown.

***Leptothorax* (D.) *pergandei floridanus spinosus* var nov**

Worker.—Length: 2.48–2.56 mm.

The worker shows its relationship to *floridanus* in that the base (dorsal surface) of the epinotum is decidedly convex and shining. The petiole when viewed laterally is very strongly convex or more node-like than with *pergandei* and lacks the central emargination on its superior border. The worker differs from the worker of *floridanus* in several characters, namely: (1) that the epinotal spines are longer and are directed upward and outward; (2) the spines are not small or tuberculate as with *pergandei* and *floridanus*, but distinctly spinose, and longer than broad at the base; (3) the pilosity is longer, coarser and more uneven; (4) the color although highly variable, is somewhat darker than that of *floridanus*. The darkest colored specimens before me, have the head, exclusive of the mandibles; the thorax, exclusive of the portion joining the head; the legs; the petiole; the postpetiole; and the gaster, exclusive of the segments from the second gastric segment to the tip, which are yellowish with dark posterior borders; black.

Described from 10 workers which were collected from a rotting pine stump at Summit, Mississippi, by Mr. L. J. Goodgame. Cotypes are in my collection, the collection of the Department of Entomology of the Mississippi A. & M. College, and the collection of Dr. W. M. Wheeler. I have named this ant *spinosus* because its epinotal spines are decidedly larger and more prominent than are the spines of the typical *pergandei* and *floridanus* and for that reason form an easy character for distinguishing it from these ants.

INSECT NUTRITION AND METABOLISM.

R. A. MUTTKOWSKI,

University of Detroit, Michigan.

At the present time, when the interest of entomologists is so sharply focused on the physiology of insects, a summary or collective review of the literature becomes a godsend. Most papers on insect physiology are distributed far and wide, often in inaccessible publications; the text-books contain only meager accounts; and the interested student experiences great difficulty in finding out exactly how much has been done. Hence a collective summary of Insect Nutrition and Metabolism, as just published by B. P. Uvarov under the auspices of the Committee on Civil Research, 2 Whitehall Gardens, London, S. W. 1., will undoubtedly be welcomed by all entomologists.

Now, it is not my purpose to write a review of this review, nor even to note its scope. My purpose is to remark politely that its chief value will lie in the bibliography, which records a trifle less than 600 titles. Nor is this note an attempt to "Condemn with polite words;" on the contrary, it is both an appreciation and a confession of disappointment.

Most every writer on subjects scientific receives a thrill when he finds his work referred to or quoted by others—that is, provided he is human. If cited incorrectly, one may shrug a patient shoulder. But if cited as sponsoring the direct opposite of what one has said—well, one is bound to reflect a bit.

Thus, on page 279 of Uvarov's summary, under the head of "The Chemical Composition of Insects and of their Products," one reads: "LEAD. Traces of lead were discovered in the blood of several insects by Muttkowski (1923), and he thought that lead is a normal constituent of insect blood."

On the following page, under the caption "ARSENIC," we read: "Muttkowski (1923) found traces of arsenic in insect blood, and thought it to be a normal constituent."

This sponsorship attributed to me was rather astonishing, for I could not recall that I had ever made statements of the sort. Reference to my 1923 paper is corroborative of this

opinion. For the very first sentence on page 134 of my paper contains a negation of what Uvarov claims of my work: "I have also found traces of arsenic and lead in several instances, but *can not regard them as normal constituents*," (italics mine). And further: "Both of these are cumulative poisons and it is probable that the specimens might eventually have succumbed. Still, *it is possible that* at least in the Coleopteron *Scobicia declivis*, which, according to Burke, Hartman, and Snyder (1922), pierces layers of lead in lead cables and may even build galleries in lead sheets, *a tolerance for lead has developed* and that *analyses would show the presence of lead* in the blood."

On page 281, under the caption "GENERAL OBSERVATIONS," Uvarov makes this statement: "A series of ash analyses made on a definite plan would give very valuable material for future studies in insect metabolism. In arranging the analyses special attention would require to be paid to the necessity of separating excretory products and ingested food from the actual constituent parts of the insect body. *This has never yet been done.*"

The italics are mine, and are intended to call attention to the fact that *it has been done*, and that the procedure is noted in the 1923 paper, which Uvarov repeatedly referred to. See page 132 of my 1923 paper. In briefest form, pages 132-134 then show my results of several hundred experiments on *insect blood alone*. I did not consider it needful to detail all these experiments nor the chemical methods used, as I was not writing a chemical text, but simply giving results that would be of interest to entomologists and physiologists. But then I *thought* I was making it clear that I was dealing with insect blood *solely*, and reading my sentences in this year 1929, I may say that I still think so.

Under the head of "Pigments," Uvarov summarizes the work done on blood pigments. Yet the summary leaves the impression that the respective authors got their results from the direct study of the blood or some particular tissue. Here I wish to repeat the caution of my 1923 paper: "Unfortunately, from the various studies it is not clear if whole specimens were used in the extraction of the pigments, or the blood alone. On the contrary, in a number of instances, large quantities of whole specimens are specifically mentioned as used for extraction. Yet it is a fact that the pigments as deposited in

the wings or epidermis, although originating from the blood, are elaborated substances of more complex composition, and hardly identical with those in solution in the blood."

I have not attempted to check up how other writers fared in Uvarov's summary. But even a hurried examination of the bibliography shows no reference to the work of Bishop on the Insect Fat Body, of Shinoda on Intestinal Secretion, of Yaga on Growth, of Sayle on Metabolism, of Taylor on Oxygen Consumption, of Fink on Respiratory Metabolism, Rich on Copper in Blood, and others. These writers have published prior to June, 1928, when Uvarov completed his paper.

As stated, my purpose is not "to condemn with polite words." In reviewing hundreds of papers, mistakes and inaccuracies may slip in easily, although in a summary it is particularly important to guard against such contingencies.

The papers involved in this note are:

MUTTKOWSKI, R. A. Studies on the Blood of Insects. I. The Composition of the Blood. Bull. Brooklyn Ent. Soc., 18: 128-136. 1923.

UVAROV, B. P. Insect Nutrition and Metabolism. A Summary of the Literature. Trans. Ent. Soc. London, Part II, 255-343, 1928. ("A limited number of separate copies are available on application to the Secretary, Committee on Civil Research, 2 Whitehall Gardens, London, S. W. 1.")

BOOK NOTICE.

DIE INSEKTEN. (Vol. VII of Brehm's Tierleben). By ERNST TASCHENBERG, completely revised by CARL W. NEUMANN; 544 pages, 8 colored plates and 64 black and white illustrations. Published by PHILIP RECLAM JUN., Leipzig.

This is the seventh volume of the memorial edition of Brehm's Tierleben, which was first published in 1863. This volume has been completely rewritten by Professor Carl W. Neumann. It is a semi-popular but entirely reliable account of the biology of insects. In this country it will be helpful to graduate students who wish to get a reading knowledge of entomological German. It sells in Germany at 6 marks (\$1.50) in linen binding, and 8 marks (\$2.00) in half leather. The last 22 pages are an index to authors quoted and to the subjects treated.

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THE FOLDED-WINGED WASPS OF THE BERMUDAS,
WITH SOME PRELIMINARY REMARKS ON
INSULAR WASP FAUNÆ.

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Through the whim of fashion, which affects Science as well as every other human institution, it has come to pass that in biogeographical studies the "ecological" aspect nowadays has the center of interest; while the purely "geographical," or distributional, method, as exemplified by Wallace's work, is being sadly neglected. To make matters worse, the professional "ecologist" gives undue prominence to the strictly physiological side of the problem, *viz.* the reaction of the organism to the environment. Other equally important topics of the animal's (or plant's) biology, such as food-habits, reproduction, enemies and parasites, seem hardly worthy of his attention. At the risk of being dismissed as antiquated by the prophets of the day, I am presenting this brief paper in support of the contention that "ecology" alone cannot teach us *all* the story of the present-day distribution of animals and plants.

It is, moreover, easy to discover one of the reasons why the modern biologist so often favors the ecological rather than the distributional method in the study of biogeography. Any inquiry into the actual distribution of animals or plants presupposes a first-hand knowledge of species, genera, and families. It necessarily calls for an intensive taxonomic specialization, to which many modern biologists are unwilling to submit. Even Wallace, fifty years ago, found it necessary to restrict his investigations almost wholly to the Vertebrates. The number of species has increased tremendously since that time, necessitating a growing complexity of classification. The present-day

student of zoogeography must of necessity limit himself to much smaller groups.

Divested of the prevailing, picturesque though rather unnecessary, terminology, the problem of plant and animal distribution comes down to that of explaining why certain types of life are to be found in a given spot of the earth's surface, while others are absent. To be wholly satisfactory, the answer to this query involves the study of three different sets of factors. The first set covers the present (or actual) environmental conditions which either permit or prevent the existence of certain types. It is with this group of factors that ecology is concerned. The second set includes the conditions that governed the past (or geological) history of each taxonomic unit and of its ancestors. Although the former distribution of animals and plants was to some extent the outcome of ecological conditions at earlier geologic periods, yet it cannot be investigated by the ecologist's methods. A third group has to do with the various factors that govern migrations. Some of these may be ecological, but others certainly are not—such as topographical conditions and the inherent urge of the species to spread beyond its borders.

I believe that a careful and detailed study of the distribution of any group of animals or plants will show how closely interwoven these three sets of factors are. Any attempt at explaining present-day distribution by selecting one set and neglecting the others, can only give a distorted picture. I shall attempt to prove this contention by a cursory examination of the island distribution of the folded-winged wasps, or Hymenoptera Diploptera.

In the following discussion, the term "wasps" or "Diploptera" will be used to cover members of the family Vespidae, which, in my opinion, comprises the following eleven subfamilies: Gayellinae, Euparagiinae, Masarinae, Raphiglossinae, Zethinae, Eumeninae, Stenogastrinae, Polybiinae, Ropalidiinae, Polistinae, and Vespinae.* I do not intend to review the wasp

*These eleven subfamilies are of more or less equal taxonomic value. Their characters have been partly indicated in a former paper, (J. Bequaert, 1918, pp. 12-17), where, however, the name Epiponinae was used for Polybiinae. If one wishes to treat the Diploptera as a distinct superfamily, the eleven subfamilies should be raised to family rank. The time-honored division of the Diploptera into three groups—*viz.*, Masarinae, Eumeninae, and Vespinae—still lingering in most text-books, is artificial and entirely inadequate for zoogeographical purposes. In the revised edition of Prof. J. H. Comstock's "Introduction to Entomology," (1924) one may find (p. 949) a characterization of the seven subfamilies found in North America.

faunæ of all islands, but shall rather select a few examples from among those that have been tolerably well investigated. The general considerations here offered have been prompted by a detailed study of the West Indian fauna, to which Dr. George Salt and I have devoted the best part of the last three years. I shall, however, only incidentally refer to this study, the results of which, it is hoped, will be published in the near future.

ECOLOGICAL FACTORS AFFECTING THE DISTRIBUTION OF ISLAND DIPLOPTERA.

The ecological factors cover all present-day environmental conditions that may affect the life of wasps— the term environmental being used in the broadest sense, to include even competition with other individuals of the same or of different species.

The peculiar conditions of an insular environment become more pronounced as the size of the island decreases. Foremost among them are the climate, which is generally of the maritime type, that is more humid and cooler (or at least more equable) than that of the neighboring mainland. In many cases insular climates are regulated by ocean currents rather than by atmospheric factors. Insular climatic conditions are unfavorable to the development of Diploptera, which are essentially a *megatherm* group, flourishing in tropical countries. In addition some subfamilies (such as the Masarinæ) and genera (such as *Pterochilus*) show a partiality to semi-arid, subtropical conditions. In the colder regions of the northern and southern hemispheres, Diploptera are very few in number. Six species and varieties of *Vespa* and one species of *Ancistrocerus* compose the entire wasp fauna of Alaska. The extreme cold of the winter and the very short summer probably account for the lack of Vespidae in Iceland (which still possesses two species of *Bombus* and several Tenthredinidæ, Cynipidæ, Chalcididæ, Proctotrypidæ, Braconidæ, and Ichneumonidæ), in Nova Zembla (which still has six species of *Bombus* and several Ichneumonidæ and Tenthredinidæ), and in Kerguelen. The distaste of the Diploptera for a cool and moist climate is well shown in the Hawaiian Islands, which possess a rich wasp fauna; yet, as Perkins (1913 *b*, p. 679) notes, no species of *Odynerus* has been able to enter the densest and wettest virgin forests of those islands, although some of the bees have occupied such forests, in spite of the sun-loving habits of the group.

The wind is a climatic factor which affects wasp-life even more directly than humidity and temperature. It is generally admitted that it tends to reduce the number of flying insects in islands that are small, low, and situated in zones of frequent gales. It is reasonable to regard this factor as accounting partly for the very small wasp fauna of most of the Antilles, especially of the Lesser Antilles, which are often visited by violent hurricanes. The apparent inability of the Diploptera to dispense with flight and to produce apterous forms has placed them at a disadvantage when compared with other groups of winged insects, such as ants, Diptera, or Coleoptera. As we shall see, the Bermudas have only three species of wasps (two of them introduced), while they still possess eleven species of ants (W. M. Wheeler, 1906). The extensive archipelago of the Bahamas has no less than 56 species and varieties of ants (W. M. Wheeler, 1905) and only ten species and varieties of wasps (according to unpublished data). In Jamaica there are some seventy species, subspecies, and varieties of Formicidæ (W. M. Wheeler, 1917) and only eight species of Diploptera. Twenty-one forms of ants have been found in Barbados (W. M. Wheeler, 1923), while the only two species of wasps of that island are probably of human introduction. Six species of ants (W. M. Wheeler, 1922) are known from Easter Island, a small island of the southern Pacific, where the only species of wasp is the widespread *Polistes olivaceus* (Degeer) (= *hebracus* Fabricius).

The darker coloration, or tendency to melanism, often exhibited by insular animals (especially by insects), has been attributed to the influence of a moist and cool climate. On the continents melanism is also frequent in regions densely covered with humid rain forests, particularly at higher altitudes in tropical mountains. I am inclined to believe, however, that the darkening of the integument is the effect of decreased insolation, owing to the increased cloudiness and the frequency of fogs, rather than of the lower temperature and higher atmospheric dampness.

The Diploptera offer us two examples of melanism in insular faunæ. The first concerns the two closely allied West Indian species, *Pachodynerus cinerascens* (Fabricius) and *P. atratus* (Fabricius), which form the peculiar subgenus *Mono-biella*, restricted to Porto Rico, the Virgin Islands and St.

Croix. These wasps are entirely black (except for an ivory white stripe over the clypeus in the male of *P. atratus*) with violaceous black wings. They have no close relatives on the South American continent or in the other Antilles and must be regarded as the offshoots of an ancient, autochthonous, Antillean stock.

The other case is that of the Hawaiian wasp fauna, the peculiarities of which will be pointed out in the sequel. In his account of the color-groups of Hawaiian wasps, R. C. L. Perkins (1913 *a*, pp. xciii-xcvii and 1913 *b*) discusses at length the melanism of these insects. He writes: "The general tendency to blackness of the Hawaiian Aculeata, as a whole, is one of their most remarkable features. The blackness of these insects is increased by the dark color of their wings, which in a large number of the species exhibits striking blue or purple reflections. The result of this is to produce a great superficial resemblance between many of the bees, wasps and fossorial wasps. Though similar phenomena appear in the Aculeates of other countries, I know no case quite comparable in extent with that observable in this fauna. We are not able to suggest any satisfactory explanation as to the cause of this widespread melanism. Were it universal it might certainly be considered protective, for the result is conspicuousness, but the allied species that lack the blackness thrive as well as those that possess it." The 35 species of Eumeninæ known from the island of Hawaii fall into three color-groups: 17 species (or 48 per cent.) are entirely black with dark wings; 10 species (or 28 per cent.) are mostly black, but with the thorax and abdomen more or less marked with reddish and the wings dark; 8 species (or 24 per cent.) are of the more usual eumenine color-type, that is black with one or two yellowish or whitish abdominal bands; but even in these, the bands are narrower than usual and the wings are more or less infusate.

The food supply is affected directly or indirectly by the amount of plant-growth. In the case of most Diploptera the effects are indirect, through the possibilities for feeding given to the insect larvæ on which the wasps prey. The only group of wasps that are strictly vegetarian—both as larvæ and as adults—is the subfamily Masarinæ, which is not represented in any insular fauna. Barring a few exceptional cases, it is a fairly general rule that the larger the island the greater will be the luxuriance of the vegetation and the variety of the flora.

We may expect that the amount of insect life will often be in direct proportion to the size of the island. The factor "food-supply" is, however, closely correlated with the mode of formation of each island. Since the larger islands are always the remnants or outliers of continental areas, their present flora and fauna are to a large extent derived from a former continental stock. As the size of the land gradually decreased through submergence, some of the autochthonous plants became extinct through the combined effects of keener competition and modified environment. The drop in the plant population was inevitably followed by a decrease in the number of insects. On the other hand, truly oceanic islands (that arose from the ocean) have been entirely populated by migrants, or waifs. Every new species of plant that settled the islands increased the possibilities for a richer insect fauna.

We can therefore only compare islands that have had a similar origin. An excellent illustration of the relation between size and fauna is afforded by the Greater Antilles, all of which are fragments of a former continental area of land. Their total wasp fauna comprises 43 species and varieties: of these 23 are found in Cuba and the adjoining Isle of Pines (area: 44,000 square miles); 15 in Santo Domingo (area: 28,250 square miles); 7 in Jamaica (area: 4,200 square miles); and 6 in Porto Rico (area: 3,500 square miles).

GEOLOGICAL FACTORS.

According to their former history, we may, with A. R. Wallace (1881), classify the islands into three main groups.

(1) CONTINENTAL ISLANDS (Wallace's Recent Continental Islands). These are islands that at some time during their geological past have been part of a neighboring continent, with which they agree in geological structure. The separation from the mainland came about either through subsidence of the coast, or through erosion, or through seismic movements. In many cases their severance is, geologically speaking, of recent date or was not complete until modern times. Often the channel which separates them from the continent is narrow, so that it is practically non-existent for powerful flying insects, such as wasps. The recent separation from, and the close proximity to the mainland sufficiently explain why the wasp faunæ of continental islands show no distinctive features.

In Europe the British Isles afford a classical example of continental islands. They became separated from northern France toward the close of the Pleistocene. Their wasp fauna comprises only twenty-five species, belonging to the Holarctic genera *Eumenes*, *Odynerus*, *Symmorphus*, *Ancistrocerus*, and *Vespa*; all the species being found on the continent of Europe. The present poverty of the wasp fauna is due to three factors: (a) the maritime, humid climate is, as I have explained before, unfavorable to the Diptoptera; (b) Great Britain was severed from the continent at the end of the last glaciation, before meridional types of wasps (such as *Discoelius* and *Pterochilus*) could migrate into western Europe; (c) much of the original fauna has undoubtedly been destroyed by man.

In North America, Newfoundland, the small islands along the coast of New England (Mt. Desert, Nantucket, Martha's Vineyard), as well as Long Island, are also of recent continental origin and their wasp fauna likewise shows no individuality.

Trinidad is perhaps the most instructive of all continental islands from our point of view. Although still included by many geographers among the West Indies, it is in reality but a detached bit of Venezuela, from which it is now separated by a broad gulf and by two channels in some places only a few miles wide. It is 55 miles long and 40 miles wide, covering an area of about 1,750 square miles. Some parts are extremely rugged, reaching an altitude of 3,012 ft. at the peak of Tucutche. It is still heavily wooded and its flora and fauna are the same as those of the Venezuelan mainland, but totally different from those of the Lesser and Greater Antilles. The South American character is well shown by the following list of species of Diptoptera at present known from Trinidad (although this is probably a mere fragment of the actual fauna): *Odynerus antillarum* Provancher, *O. (Stenodynerus) cyphosus* Zavattari, *Pachodynerus praecox* (H. de Saussure), *Eumenes cinctus* Provancher, *E. flavopectus* Provancher, *E. impunctus* Provancher, *Monobia* (two apparently undescribed species), *Apoica pallida* Lepeletier, *Synoeca surinama* (Linnaeus), *Polybia bifasciata* H. de Saussure, *P. occidentalis* (Olivier), *P. rejecta* (Fabricius), *Polistes canadensis* (Linnaeus) (typical color phase), and *P. pacificus* var. *geminatus* Fox. Only two of these species are known from the Antilles, viz., *Polybia occidentalis*, which has invaded the southernmost of the Lesser Antilles (Grenada and, perhaps, St. Vincent);

and *Polistes canadensis*, of which a peculiar color phase (var. *cinctus* Lepeletier) is characteristic of most of the Lesser Antilles. These two exceptions rather confirm than impair the view that Trinidad (as well as Tobago and the archipelago of Curaçao) must be eliminated from any consideration of the West Indian fauna.

(2) RESIDUAL ISLANDS (Wallace's Ancient Continental Islands). The islands of this second group are remnants of a former continent that, after a shorter or longer history as such, subsided for the most part beneath the ocean, leaving only an archipelago or a series of disconnected islands. The fauna of such islands possesses, as a rule, a number of relics or residual forms of life which give it a marked individuality. In most cases too, they have been separated from the nearest continent for a long time. Their fauna is often not homogeneous; but in addition to the descendants of an old autochthonous stock, they may contain elements that were brought in by ancient and recent migrations.

Corsica and Sardinia, in the western Mediterranean, are the remnants of a continent (Tyrrhenis) that persisted throughout most of the Tertiary, when it was connected with southern France and Tuscany. The wasp fauna of these islands consequently differs little from that of southern Europe.

The Greater Antilles (Cuba, Jamaica, Santo Domingo, and Porto Rico) formed toward the close of the Tertiary one very large island (Antillea), which may have been at various times connected with southern Florida and Yucatan. The original fauna of this continent was probably very rich, as shown by the numerous fossils. Even at the present time it shows much variety in certain groups, such as terrestrial mollusks. It is, however, rather poor in insects. According to a careful study of abundant material by Dr. G. Salt and myself, the Dipteropterous fauna of the Greater Antilles comprises 37 morphological species (two of them doubtful) and 6 color varieties. Of these 43 forms, 36 (or 83 per cent.) are restricted to the Greater Antilles, 4 are also found either in the Bahamas or in some of the Lesser Antilles, and 3 only extend outside the West Indian Subregion. Most of the endemic species appear to have no close relatives elsewhere and we regard them as the offspring of the primitive, autochthonous, Antillean wasp fauna. A few species may have been derived from ancient immigrants

from the continent, since they have had time to develop into endemic, though closely allied, forms. The Antillean *Polistes crinitus* (Felton) and its several color phases (one of which has invaded the southeastern United States) are structurally very similar to *Polistes versicolor* (Olivier), the males alone presenting some slight morphological differences. These two species certainly had a common ancestor which may have migrated from Central America to Jamaica, Santo Domingo, Porto Rico, and the Bahamas. That *P. crinitus* was not a member of the autochthonous fauna of Antillea is indicated by its being absent from Cuba. Finally *Pachodynerus nasidens* (Latreille) appears to be a very recent migrant into the Greater Antilles, where it may have been introduced by the agency of man.

Madagascar, the neighboring archipelagos of the Comoros, Seychelles, Amirantes, Aldabra, and some other smaller islands are the remainders of a very large continent that at one time occupied much of the Indian Ocean and was broadly connected with East Africa. It probably became separated from the African continent about the middle of Mesozoic times. The actual fauna of these islands presents so many striking peculiarities that some zoogeographers have regarded them as forming a distinct "Malagasy Region." The affinities of the wasp fauna, however, are Ethiopian, though endemism is extremely pronounced. There are about 65 species and color varieties of Diploptera belonging to the genera *Labus* (2), *Eumenes* (4), *Pachymenes* (1), *Odynerus* (11), *Belonogaster* (10), *Ropalidia* (30), and *Polistes* (7). Of these 65 forms, 57, or 87 per cent., are endemic; the remaining 8 forms comprising four endemic color phases of Ethiopian species, two forms widely distributed on the African continent, and two species known from the Oriental Region. The two Oriental types, *Polistes macaensis* (Fabricius) and *Odynerus trilobus* (Fabricius), are, I believe, recent immigrants into the Malagasy islands, where they were perhaps imported by man. Although there are no endemic Malagasy genera of wasps, the individuality of the fauna is greatly enhanced by the numerous species of *Belonogaster* and *Ropalidia*, some of which have peculiar leaf-green color markings found nowhere else throughout the range of these genera. It should be noted that while *Ropalidia* is found throughout the Old World tropics, *Belonogaster* is a strictly Ethiopian genus. The most important difference from the wasp fauna of the

Ethiopian continent is negative, *viz.* the absence in the Malagasy islands of the genus *Synagris*, the most truly Ethiopian type of wasp, as well as of *Raphiglossa*, *Zethus*, *Paramischocyttarus*, *Polybioides*, and the subfamily Masarinæ, all of which are well represented on the African mainland.

(3) OCEANIC ISLANDS. Many islands, especially among those of small size, have never had any connection with a continental land-mass, but have arisen in mid-ocean. They either are the product of volcanic eruptions (as in the case of the Hawaiian Islands) or have been built up from slowly emerging coral reefs (as, for instance, the Bermudas, the Bahamas, and many of the low islands in the South Seas). It is evident that, as Wallace states, "all the animals which now inhabit such oceanic islands must either themselves have reached them by crossing the ocean, or be the descendants of ancestors who did so." The factors which influence possible migration of Diptera to oceanic islands will be examined later. It should be kept in mind that the mode of formation and not its distance from a continental shore, decides the oceanic nature of an island.

The wasp fauna of most truly oceanic islands is known to be very scant, even considering the insufficient exploration of the entomology of many islands. The case of the Bermudas will be examined at length in the sequel. In the West Indies, the Bahamas, although arising from an extensive bank that probably at one time connected Florida with Cuba, yet are entirely of oceanic formation, being built of coral limestone and wind-drift. They consist of numerous islands covering about 5,700 square miles of dry land. As known at present, the Bahaman Diptera comprise 10 species and varieties, half of which are endemic, the others being found in Cuba also. The endemic forms are, however, very closely allied to species of Florida or Cuba, from which they have been derived at some comparatively recent date. The rather large wasp fauna of the Bahamas is due to the extent of the archipelago and to the proximity of some of the islands to either Florida, Cuba, or Santo Domingo.

Owing to the untiring zeal of R. C. L. Perkins no insular insect fauna is better known than that of the Hawaiian, or Sandwich, Islands. Fortunately for our purpose this archipelago possesses an unusually rich wasp fauna. It consists

of eight larger islands and a number of islets and reefs, scattered over a distance of about 1,800 miles, a little within the Tropic of Cancer. They are among the most isolated portions of land surface, the nearest continent being North America, about 2,100 miles away. Even the nearest islands are still very remote and separated by enormous depths of ocean. The whole archipelago is of oceanic origin, built up by volcanic eruptions in mid-ocean. Disregarding the many introductions by man, the whole of the flora and fauna is due to immigration, ancient and recent.

The insect fauna of the Hawaiian Islands is exceptionally rich. Perkins, in 1912, knew 3,325 species, 2,740 of which he regarded as belonging to the natural fauna. He estimated that about half of the existing species of native insects had been collected at that time. A number of factors have contributed to the richness of the fauna. In the first place, the archipelago is certainly very old. Volcanic eruptions have produced islands in this region since the remotest geological periods. Some of the islands have thus become quite extensive, Hawaii, for instance, covering an area of 4,015 square miles, but little less than that of Jamaica. The general mountainous character and the high altitude cause much variety of ecological conditions. There is a great diversity of climate and on many of the islands the rainfall is abundant. The vegetation was originally quite luxuriant and is still so in many parts. Of the large number of flowering plants at least 80 per cent. are endemic.

The endemic hymenopterous fauna of these islands has been so ably discussed by Perkins (1913 *a*, pp. lxxiii-cxi) that it is unnecessary to review it here in detail. The most striking feature, perhaps, is the complete absence of certain large groups, such as *Chalastogastra*, *Cynipinae*, *Psammocharidae*, *Chrysididae*, *Mutillidae*, and *Scoliidae*. Other groups such as *Formicoidea*, *Proctotrypidae*, *Pteromalinae*, and *Braconidae*, are represented by only a single species that can claim endemism. All the truly indigenous bees, or *Apoidea*, belong to the family *Prosopidae*. Among the fossorial wasps, or *Sphegoidea*, only the *Pemphredoninae* and *Crabroninae* are represented by endemic species.

The *Diploptera* now found in the Hawaiian Islands comprise first a small number of species imported by man. These are

three Polistinae: *Polistes olivaceus* (Degeer) (= *hebraeus* Fabricius), *P. macaensis* (Fabricius), and *P. fuscatus* (Fabricius) var. *aurifer* (H. de Saussure); one of the Vespinae, *Vespa occidentalis* Cresson; and one of the Eumeninae, *Pachodynerus nasidens* (Latreille) (= *P. simplicicornis* H. de Saussure).*

The autochthonous, or endemic, wasp fauna consists of 112 species, a greater number than that belonging to any other group of indigenous Hymenoptera. These species all belong to the Eumeninae, a subfamily of solitary Diploptera, and represent two genera only, viz. *Pterochilus*, with three, and *Odynerus*, with 109 species. Both these genera are cosmopolitan.† Not the least remarkable feature of this rich wasp fauna is the preciseness of the structural characters which differentiate these many species. Whereas in other parts of the world the species of *Odynerus* differ often in a few obscure morphological details, most of the Hawaiian forms offer very distinct structural characters. On the other hand, many of these insects are much alike in coloration, the whole Hawaiian wasp fauna having become divided into a small number of color-groups. The general tendency to melanism of many species has been alluded to before. Endemicity is very pronounced in most of the islands of the group, as appears from the following figures, which also show a distinct correlation between the size of each island and the number of species it possesses. Hawaii (4,015 square miles) has the largest wasp fauna, with 35 species, 29 of which (or 83 per cent.) are endemic. Oahu (598 square miles) comes next with 29 species, 26 of them (or 90 per cent.) endemic. Maui (728 square miles) has 26 species, 9 of them (or 34 per cent.) endemic. Molokai (261 square miles) has 24 species, 9 of them (or 37 per cent.) endemic. Kauai (slightly smaller than Oahu) has 17 species, all of them (or 100 per cent.) endemic. Lanai (much smaller than any of the others) has 13 species, only 3 of them endemic. It should be noted that Lanai, Maui, and Molokai lie close together and have many

*Through the kindness of Dr. F. X. Williams, I have been able to examine Hawaiian specimens of these five species.

†Perkins has created for eight of the Hawaiian species of *Odynerus* a "genus" *Nesodynerus* and for one other species, a "genus" *Chelodynerus*. The characters on which these groups are based are not, in my opinion, of generic value. The three Hawaiian species of *Pterochilus* have been placed by Perkins in a special "genus" *Pseudopterocheilus*. As long ago as 1866, it was recognized by F. Morawitz that in many species of *Pterochilus*, the female alone has ciliated or fringed labial palpi.

species in common; if treated as one area, their combined fauna has 40 species of Eumeninæ, 34 of which (or 85 per cent.) are not found elsewhere. The very high endemicity of Kauai (notwithstanding the small number of known species) is probably due to its being much farther away from its nearest neighbor than is the case of any of the other islands.*

FACTORS REGULATING INSULAR MIGRATION.

Most continental islands are so close to the mainland, that insects have, as a rule, no difficulty in reaching them either by flight or in drift. Migration in this case differs but little from the spreading of the species over continental areas. In residual islands, however, the autochthonous fauna may be added to from time to time by chance arrival of waifs from the continents or from other islands. Finally, true oceanic islands have been populated by waifs only. As the chances for new arrivals are in direct proportion to the length of time the island has been emerged, the age of the island will, as a rule, be of considerable importance in determining the size of its insect fauna.

The natural means of dispersal of flying insects are as yet insufficiently known. In the case of Diploptera some species undoubtedly have reached islands by flight, while others were carried in the larval or pupal stages within their nests attached to or hidden in drift. It is difficult to estimate which of these two methods has been most effective. We are but poorly informed as to the actual power of flight of wasps and it might be incorrect to draw conclusions from analogous observations with bees or with flying insects of other orders. Many wasps are rather clumsy fliers, especially when compared with some of the solitary bees, such as *Anthophora*. The wind is generally regarded as helpful in the dispersal of insects by flight. In the case of wasps with long and broad wings, however, it is a question whether even a moderate gale will not hamper rather than aid them, when they are blown to sea. If they lose control of their flight they will be drowned before they are many miles off shore. I am inclined to believe that the majority

*The figures here adopted differ slightly from those given by Perkins. They are based upon a careful checking up of all published records. The total number of 112 species does not include *Odynerus hawaiiensis* Blackburn and Cameron, a name which has not been properly accounted for; but the species on which it was based has certainly been described later by Perkins.

of native wasps of oceanic islands have been derived from nests that were carried in drift by ocean currents. It is significant that most of the endemic wasps of such islands belong to the Eumeninæ, a subfamily of solitary *Diploptera* containing many species that in the early stages live within well-sealed cavities or burrows in dead wood. The relative efficacy of wind and drift in bringing new wasps to a given island, will of course be conditioned by the direction of the prevailing winds and ocean currents, as well as by the distance from continents or other islands.

Whereas purely ecological factors are of minor importance in the process of migration, they will be foremost in deciding the ultimate fate of the new immigrants. What will happen to the waifs depends largely upon their adaptability to the new environment. As pointed out by Wallace (1881, p. 73), most insects have become so exactly adapted to one set of conditions that when carried into a new country they cannot live. Such over-specialization is not yet apparent among most groups of *Diploptera*, except in the case of the Masarinæ, whose food supply—for the larvæ as well as for the adults—is wholly derived from the nectar and pollen of certain flowers. The other *Diploptera* are still what might be called "generalized predators." Their food consists entirely or mainly of insects and every species has a rather wide range in choosing its prey. On the other hand, as I have indicated, wasps have been handicapped by their distaste for the cool and moist climate so frequent in most small islands, as well as by their apparent inability to evolve wingless forms.

The offspring of a continental species that reached an island as a waif or that was left stranded in a residual fauna, will in the course of time develop new specific forms through the usual processes of variation and natural selection. The products of this evolution will in most cases show a decided difference from the contemporary offspring of the same stock on the continent or on other islands. It is generally admitted that this process of evolution is either hastened or accentuated through the isolation of the insular fauna. As B. L. Robinson (1902) has shown, in an isolated flora or fauna specific variations may go on without restriction, except for the chance arrival of waifs of the same species from the continents; but the new waifs being in a small minority would probably be unable to

check any variation that had begun before their arrival. Insular wasp fauna offer some beautiful examples of the effects of isolation. The case of the Eumeninæ of the Hawaiian Islands has been discussed before. The genus *Eumenes* contains two well-defined species, each restricted to an island and yet clearly derived from a widely distributed ancestor. *Eumenes allurudi* Pérez is a precinctive species of the Seychelles and Gloriosa Islands, which finds its nearest relative in the African *E. maxillosus* (Degeer) (See J. Bequaert, 1921). A parallel case is afforded by *Eumenes germaini* Lucas, endemic in New Caledonia and the Loyalty Islands and evidently derived from the common, Oriental species, *Eumenes pyriformis* (Fabricius). It is of interest that in both cases these precinctive species of *Eumenes* replace what apparently is their ancestral form, which still occurs in neighboring islands. For, although color phases of *E. maxillosus* are common in Madagascar and the Comoros, none have been collected in the Seychelles and Gloriosa Islands. Likewise the color phases of *E. pyriformis* are absent from New Caledonia and the Loyalty Islands, while still occurring in the New Hebrides.

Almost every island now contains in its wasp fauna one or more species that have been imported by man. In the discussion of any insular fauna it is essential to recognize these as such. As Perkins rightly remarks, owing to our very incomplete knowledge of the insect fauna of the world, some of the introduced species may not yet be recognized outside the particular island whose fauna is being investigated. The current, unfortunate tendency to describe every trifling variation as a new "species" or "race," also helps to obscure the problem.

Polistes is a genus of social wasps which is at present found in almost every island with a temperate or warm climate. While the species that show morphological characters are relatively few in number, they often vary tremendously in color, so that they have led to the introduction of many names. For instance, over one hundred so-called "specific" names have been proposed for the *Polistes* of North and South America, but it is doubtful whether there are more than thirty valid species in the New World. When specimens of *Polistes* have been collected in islands they have generally been described as new, endemic species. Thus we have *Polistes ridleyi* Kirby, described from Fernando de Noronha, an islet of the Atlantic, 200 miles

off Cape San Roque; and *Polistes fortunatus* Kirby, described from the Cape Verdes. An examination of the type of *P. fortunatus* has shown that this wasp is a color phase of the American *Polistes fuscatus* (Fabricius), and there can be little doubt that it was imported into the Cape Verdes by man. Moreover, some species of *Polistes* are rather readily carried by ships into new territory, owing to their habit of frequenting human habitations where they often build their paper nests. The European *Polistes gallicus* (Linnaeus), for instance, is not now a member of the indigenous fauna of the British Isles; yet specimens are captured from time to time in England. Perkins (1917, Ent. Mo. Mag., LIII, p. 229) suspects that it "has been not infrequently brought over [to England] with shrubs or in other ways, and has once in a while started a colony only to be sooner or later exterminated by our climate." In his interesting study of the migration and dispersal of insects, J. W. Tutt (1902, Ent. Record, XIV, p. 208) writes: "A South American wasp, *Polistes bipustulatus* [a color phase of *P. versicolor* (Olivier)], was taken at Ince, near Liverpool, during an excursion of the Liverpool Nat. Field Club, in the summer of 1875; the same species had been taken in the London Docks by Douglas, in 1868, whilst in Ent. Ann., 1868, p. 87, and 1869, p. 68, the same Brazilian species is recorded as being taken at Penzance in 1866 and 1867, undoubted importations." As we have seen, three species of *Polistes* have been imported by man into the Hawaiian Islands: *P. olivaceus* (Degeer) and *P. macaensis* (Fabricius) came from the Oriental Region, while *P. fuscatus* var. *aurifer* (H de Saussure) was brought from California. One of these species, *P. olivaceus* (Degeer) (= *hebraeus* Fabricius), appears to have unusual facilities of travel. It is now so widespread throughout the Oriental and Australian Regions and Polynesia, that its original home is difficult to define. That it owes its occurrence in many islands to accidental introduction by man is beyond doubt.

THE BERMUDAS.

The Bermudas, also called Somers or Summer Islands, are a compact archipelago of nearly three hundred islands, cays, and reefs, isolated in the Atlantic Ocean, in north latitude 32° 14' to 32° 23' and in west longitude 64° 38' to 64° 52'. The nearest land at Cape Hatteras, North Carolina, is 568 nautical miles

(or 620 statute miles) to the west; the distance to the nearest West Indian island (Abaco, in the Bahamas), is about 700 nautical miles (or 850 statute miles). The emerged land covers an area of a little over nineteen square miles. At one time the archipelago was much more extensive, for the outer reefs are the eroded remains of limestone islands larger than any of those still left. All the solid rock now at or near the surface is an Aeolian limestone, of recent geologic age, made of a hardened mixture of coral, shells, and sand, drifted by the wind. Many caves and grottoes have been eroded in these rocks. A deep-well boring has shown that at about 360 feet below the surface, the limestone cap rests upon rocks of volcanic origin. Loose superficial soil is scarce, but there are still a few moving sand-dunes. The islands are hilly, the hills being consolidated sand-dunes, many reaching over 200 feet. The highest point is 268 feet above sea-level. There is no permanent running or standing fresh water.

As in all low islands of small extent, the climate is dominated by the temperature of the surrounding waters. Being in the path of the warm waters of the Gulf Stream, the Bermudas have a remarkably equable climate for their latitude. In winter and spring the temperature averages 59° F. to 66° F.; frosts are exceptional and light. In summer the average rises to 81.7° F. The annual average is about 70° F. The total rainfall averages 51.4 inches a year and is fairly evenly distributed over the seasons. It is greatest in winter, when cold, northerly winds prevail. During the summer showers are few and of brief duration, but the air is then moist and sultry. Perfectly calm days are rare; the winds are often very strong and hurricanes occasionally visit the islands.

When first discovered by Europeans, about the year 1510, the Bermudas were uninhabited and all densely wooded with cedars (*Juniperus bermudiana* Linnaeus) and palmettoes (*Sabal Blackburnianum* Glazebrook). The islands are now denuded of forest and have become dry and barren, being covered with hardy shrubs and grasses. There are extensive stretches of cultivated land. The native flora of the Bermudas originated from seeds, spores or other parts brought from the North American mainland or from the West Indies by the natural agencies of wind, ocean currents, and birds. The present flora comprises about 449 species of flowering plants, but of

these only 146 are regarded by N. L. Britton as having reached the Bermudas independently of human activities. There are very few endemic flowering plants (11 species in all), the most noteworthy being the cedar and the palmetto. Even including the cryptogamic plants, only 8.7 per cent. of the total native flora is endemic; while about 80 per cent. of the native land plants inhabit the West Indies or southern Florida, or both.*

According to A. E. Verrill, the pre-Pliocene fauna and flora was exterminated by the Glacial Period, so that most of the present native life reached the islands since the latter part of the Pleistocene. The terrestrial fauna is very poor, even for oceanic islands. Much of it has probably been destroyed by man. We know that this happened to several of the indigenous birds. The changes in ecological conditions which followed deforestation undoubtedly caused the disappearance of many species of insects. On the other hand, some of the birds, reptiles, amphibians, and insects that were accidentally or purposely introduced by man may have killed off some of the native insects. Some of the tramp species of ants are particularly powerful agents of extermination. (See W. M. Wheeler's notes on *Pheidole megacephala* Fabricius in the Bermudas). Finally, no serious investigation of the land fauna of the Bermudas has as yet been attempted.

For all these reasons one must be cautious in attempting to discuss the origin of the Bermudan insect fauna. Condensing the information available in 1902, A. E. Verrill states that of the 225 species of insects identified from the islands, more than 90 per cent. belong also to the fauna of the United States; a few are European; perhaps a dozen are peculiarly West Indian, and two only are precinctive. One of these is the large locust, *Tibicen bermudiana* (Verrill), which was mentioned as early as the year 1619. It is closely allied to *Tibicen lyricen* (Degeer), of the eastern United States, though distinct. W. T. Davis (1919, Jl. New York Ent. Soc., XXVII, pp. 242-243) has expressed the opinion that *T. bermudiana* is probably the result of a stray *T. lyricen* having reached the Bermudas at a remote period. Many of the species listed from the islands are either domestic or at least cosmopolitan insects. Verrill concludes from his review: "The relatively small number of species

*For a general account of the Bermudas, consult A. E. Verrill (1902-1903). The flora has been fully treated by N. L. Britton (1918).

hitherto obtained is very remarkable and is good evidence of the very meager insect fauna, though many species must still remain to be discovered." (1902-1903, p. 740).

THE HYMENOPTERA OF THE BERMUDAS.

The following brief discussion of the Bermudan Hymenoptera, other than Diptoptera, is based partly upon published records, especially those contained in papers by A. E. Verrill (1902-1903), W. M. Wheeler (1906), and L. Ogilvie (1928*b*). I have, however, also used unpublished data found in three collections. One of these was made by Mr. Austin M. Brues in 1913; the two others are in the Museum of Comparative Zoology of Harvard University, one made by Miss E. B. Bryant during July and August, 1921, and the other by Mr. W. S. Brooks in January and February, 1928.

In the Aculeata, the bees are represented by three species. One of these, the honey-bee (*Apis mellifera* Linnaeus), was introduced by the early settlers (before 1679). The other two appear to be endemic or at least to have reached the islands by natural means. They are both solitary bees. *Halictus semi-viridis* Friese (1908, Zool. Jahrb., Suppl. Bd. XI, 1, p. 37) is a small species, which, as pointed out to me by Miss Grace Sandhouse, seems to be more like some of the North American species (particularly *H. nymphaearum* Robertson) than any of the West Indian. It is a common insect, as I have seen many specimens of it, including the undescribed male. It is the *Augochlora* and *Halictus* of Ogilvie's list. Ogilvie also mentions having found an undetermined species of *Megachile* nesting in walls and a female of what is probably the same species of bee was collected by Mr. Austin Brues.*

Only three species of fossorial wasps are known from the islands. Two of them are most probably recent introductions by man—viz., the Sphecidae, *Sceliphron caementarium* (Drury) (= *Pelopaeus flavipes* and *Sceliphron fasciatum* of Verrill's list) and *Chalybion cyaneum* (Klug) (= *Chalybion caeruleum* of authors, not of Linnaeus). Both are common mud-daubers of the eastern United States, that often nest in houses or even on board ship, the mud nests being easily transported with timber

*The specimen collected by Mr. Austin Brues has now been described as *Megachile pruina bermudensis* Mitchell, 1929, Psyche, XXXVI, p. 93.

or in furniture. The *Sceliphron* appears to be the more common of the two in the Bermudas and is the only one included in Miss Bryant's collection. According to F. Kohl (1918, Ann. Naturh. Hofmus. Wien, XXXII, p. 117), the Bermudan specimens belong to the typical color form of *S. caementarium* (Drury). The third fossorial wasp is a small species of the family Psenidæ (or Mimesidæ) and belongs to the subgenus *Mimesa* of the genus *Psen*. The pair collected by Miss Bryant show that it is very closely allied to *Psen* (*Mimesa*) *niger* Packard, of the eastern United States, if not identical with that species. Since some of the species of *Psen* are known to nest in wood or in the pith of twigs, they may be transported in drift. The possibility of the Bermudan *Psen* being a human introduction can, however, not be entirely excluded.

F. Dahl (1892) recorded from the Bermudas a digger wasp of the family Psammocharidæ, which he referred to the common North American species, *Psammochares philadelphicus* (Lepeletier). Ogilvie however, did not find this species, but he lists instead *Psammochares funereus* (Lepeletier) and *P. scelestus* (Cresson). In the collection made by Mr. Austin Brues, I find three females of a *Psammochares* belonging to the subgenus *Anoplius* and apparently quite closely allied to the common *P. virginensis* (Cresson) of the eastern United States.

The family Formicidæ, or true ants, is one of the few groups of Bermudan insects that are tolerably well known. W. M. Wheeler (1906) lists eleven species as reported from the islands, but three of these he had not seen himself. All belong to the cosmopolitan or tropicopolitan genera, *Ponera*, *Odontomachus*, *Monomorium*, *Cardiocondyla*, *Pheidole*, *Tetramorium*, and *Prenolepis*, the New World genus, *Brachymyrmex*, and the Holarctic genus, *Lasius*. Most of these ants are widely distributed species, several of them being well-known tramps. The single endemic ant, *Prenolepis kincaidi* Wheeler, is regarded by Wheeler as probably of West Indian origin.

Of parasitic Hymenoptera, the families Evaniidæ, Ichneumonidæ, and Chalcididæ are represented. One of the cosmopolitan cockroach parasites of the genus *Evania* appears to be common. Verrill and Ogilvie refer the species to *E. appendigaster* (Linnaeus) (= *E. laevigata* of Jones, 'Guide,' p. 142). Since, however, a second species, *E. punctata* Brullé (= *E. urbana* Bradley), is equally common in the cities of

the eastern United States, the specific identity of the Bermudan insect should be more carefully investigated. Unfortunately there are no specimens in any of the collections that I have examined. Both these cockroach parasites have been imported by man from the Old World in the egg-cases of their hosts.

In the collections which I have seen, there are at least five species of Ichneumonidæ (belonging to four genera), five species of Braconidæ (belonging to as many genera), and five species of Chalcididæ (of the subfamilies Chalcidinae, Eurytominae, and Pteromalinae). Verrill states that several undetermined Ichneumonidæ were obtained and adds: "Among them is a species of *Ophion* very much like our common large species (*O. macrurus*).\" (1902-1903, p. 754). On p. 889, he lists in the Addenda "two small Ichneumon-flies, of the genera *Limneria* and *Cratichneumon*, determined by W. H. Ashmead; and two other species.\" The so-called *Ophion* is a species of *Enicospilus*, a genus with many representatives in North America and the West Indies. Ogilvie refers the Bermudan species to *E. concolor* (Cresson); but a female taken by Mr. Brooks has been identified as *E. flavus* (Fabricius) by Professor C. T. Brues. It certainly agrees with the description and figure given by C. W. Hooker (1912, Trans. Amer. Ent. Soc., XXXVIII, p. 71, Pl. III, fig. 24) of *E. flavus*, a species widely distributed on the American continent (from New Jersey to the Guianas), as well as throughout the West Indies. The very large ocelli indicate that this parasitic wasp, like so many other Ophioninae, is nocturnal or crepuscular. Ogilvie also lists *Paniscus rufus* Brullé as taken by him in the islands. Of Braconidæ, Ogilvie records *Opius humilis* Silvestri, introduced from the Hawaiian Islands to control the Mediterranean fruit-fly, *Ceratitis capitata* (Wiedemann) (see Ogilvie, 1928a); *Apanteles solitarius* (Ratzeburg), *Aphidius testaceipes* (Cresson), *Diacretus rapæ* (Curtis), *Calyptus* sp., and *Phanerotoma* sp. Among the Chalcididæ he lists one species of Eupelminæ: *Lecaniobius cockerelli* Ashmead; and four species of Aphelininae: *Aphelinus diaspidis* Howard (introduced in 1921-1924); *Prospaltella berlesei* Howard (introduced in 1921-1924); *P. diaspidicola* Silvestri (introduced in 1921-1924); and *Coccophagus flavoscutellum* Ashmead.

The following important groups of Hymenoptera have no known representatives in the Bermudas: Chalastogastra, Proctotrypoidea, Cynipoidea, Chrysididæ, Mutillidæ, and Scoliidæ.

THE DIPLOPTERA OF THE BERMUDAS.

The folded-winged wasps, or Vespidae, are represented in the Bermudan fauna by three species only, viz. *Vespa arenaria* Fabricius, *Polistes fuscatus* (Fabricius), and *Odynerus bermudensis* Bequaert. The *Vespa* and the *Polistes* have evidently been introduced by man from the North American continent. The *Odynerus*, here described for the first time, may be endemic; but its affinities are with the North American, not with the West Indian, fauna.

1. *Vespa arenaria* Fabricius.

Vespa arenaria Fabricius, 1775, Syst. Entom., p. 365 (sex not given). J. Bequaert, 1928, Bull. Brooklyn Ent. Soc., XXIII, p. 54, (worker, holotype of Fabricius). *Vespa diabolica* H. de Saussure, 1853-1855, Et. Fam. Vesp., II, p. 138 (♀ ♂). R. du Buysson, 1905, Ann. Soc. Ent. France, LXXIII, 4, p. 571, Pl. VI, Fig. 4. *Vespa vulgaris* J. M. Jones, 1876, 'The Visitor's Guide to Bermuda,' p. 142, (not of Linnaeus).

I have seen one of the workers of this yellow-jacket collected by J. M. Jones in the Bermudas and sent by him to the Peabody Museum. It is now at the Museum of Comparative Zoology. The species does not appear to have become naturalized in the island, since none of the later collectors have seen it there.

V. arenaria is extremely common throughout North America from the Atlantic to the Pacific coast and from southern Alaska to New Mexico.

2. *Polistes fuscatus* (Fabricius).

Vespa fuscata Fabricius, 1793, Entom. Syst., II, p. 260, (sex not given). *Polistes perplexus* Cresson, 1872, Trans. Amer. Ent. Soc., IV, p. 245, (♂). W. F. Kirby, 1884, Ann. Mag. Nat. Hist., (5) XIII, p. 410. Verrill, 1902-1903, Trans. Connecticut Ac. Arts Sci., XI, 2, p. 751, Figs. 106 (♂) and 107 (♀). Ogilvie, 1928, 'The Insects of Bermuda,' p. 49. *Polistes pallipes* J. M. Jones, 1859, 'The Naturalist in Bermuda,' p. 113. Ogilvie, 1928, 'The Insects of Bermuda,' p. 49. *Polistes canadensis* J. M. Jones, 1876, 'The Visitor's Guide to Bermuda,' p. 142, (not of Linnaeus). *Polistes bellicosus* Ogilvie, 1928, 'The Insects of Bermuda,' p. 49, (not of Cresson).

Polistes fuscatus was originally described from the Antilles and I have seen specimens from Barbados that agree quite well with Fabricius' description. In coloration they can be easily matched with some of the Bermudan specimens. I have also seen two males, similarly colored, from Jamaica. Moreover, I regard the Antillean and Bermudan *P. fuscatus* as

specifically identical with the common North American species generally called *Polistes pallipes* Lepeletier and its multiple color phases. I am unable to find structural characters that might separate these several color forms in either sex. One of the color phases of this "species" has been described by Cresson from Texas as *Polistes perplexus*, and the differences in color between this insect and typical *P. fuscatus*, of the Antilles, are so slight that I do not believe it possible to regard *perplexus* even as a distinct color phase.

In North America the *fuscatus-perplexus* coloration is not restricted to Texas, but I have seen similarly colored specimens from Mississippi, Alabama, Virginia, and New Jersey. Moreover, one may find every gradation in color to the var. *pallipes* (Lepeletier) which represents the extreme melanistic color phase of *P. fuscatus*. The many color variations of *P. fuscatus* in North America, as well as the synonymy of this species, will be discussed in the forthcoming revision of the West Indian wasps.

In view of the fact that *P. fuscatus* is the most common social wasp of North America, while in the West Indies it has been taken only in Barbados (where it is common) and in Jamaica (where it is very rare), I am inclined to regard this wasp as not a true member of the West Indian fauna, but as having been introduced by the agency of man into Jamaica and Barbados, as well as into the Bermudas. It was most probably carried from the coast of Virginia or the Carolinas to the Bermudas and thence to Barbados. Historical accounts show that at one time many vessels traded between the Bermudas and the West Indies, especially Barbados.

P. fuscatus is, as J. M. Jones (1872, p. 142) states, "the most common insect of the order Hymenoptera" in the Bermudas. It is present in all the collections made in the islands. I have seen many females, workers, and males obtained by H. H. Whetzel, T. S. Bradlee, F. M. Jones, H. F. Schwarz, and Miss E. B. Bryant. According to Ogilvie its vernacular name is "Spanish bee." The coloration of all these Bermudan specimens is rather uniform and has been fully described by A. E. Verrill (1902-1903). The two yellow, longitudinal stripes of the propodeum, however, are more often lacking than present. It is noteworthy that, in the female and worker, the clypeus, inner and outer orbits, oculo-malar spaces, and mandibles are

pale yellow, very slightly suffused with ferruginous, which is also true for the specimens from Barbados.

In his 'Naturalist in Bermuda' (1859, p. 113) J. M. Jones gives an interesting account of the habits of *P. fuscatus*, which, he says, is "commonly known to the inhabitants as the 'Bermuda Wasp.' The nest, or, more properly speaking, comb, of this species, is usually fastened to the branches of the wild sage (*Lantana salvifolia*), and is about the size of a man's hand; flat, with its upper surface shiny and apparently waterproof, having the mouths of the cells reversed, or opening beneath, of which we counted some two-hundred and eighty in a specimen we brought home and presented to the British Museum. When constructing their combs in the cedar groves and cultivated parts, they appear to choose the proximity of a wall, in preference to the open, perhaps for shelter from the winds. Mr. Hurdis informs us that their combs abound in the marshes, where they hang suspended from the stems of the tall sedges. It is a cowardly insect, and is not half the plucky fellow our English wasp is, who always guards his nest with vigilance, and attacks the intruder with the greatest fury; but our friend of Bermuda will not only let you come close to his comb, but will positively allow you to cut off the branch whereon his abode rests, without any molestation on his part. It is prettily marked, of a lightish brown color, striped with bands, brown and buff, across the abdomen."

3. *Odynerus (Stenodynerus) bermudensis*, new species.

A small, cylindrical species. Black; with the legs, first tergite, and lateral spots on the second tergite, ferruginous red; head and thorax with a few yellow markings, the first and second tergites and second sternite with an apical yellow fascia.

Length (h. + th. + t. 1 + 2): ♀, 6.5 mm.

Female: Head, seen in front, subcircular, a little higher than wide; seen from above, transverse but long, about twice as wide as long, not wider than the thorax; occipital margin with a shallow inward curve. Vertex and cheeks margined throughout by a carina which is well-marked on the occiput and much higher along the cheeks. Cheeks wide and slightly swollen in their upper half, where they are but little narrower than the upper part of the eye in profile, considerably narrowed at the lower third, where the marginal carina forms a very faint obtuse angle. Inner orbits one and one-half times as far apart on the vertex

as at the clypeus. Upper half of the frons much swollen. Ocelli in a flattened triangle, the posterior pair as far apart as from the eyes. Interocellar area with a shallow, broad depression, the sides of which are slightly raised near the posterior ocelli. Vertex without fovea. Antennæ twice as far apart as from the inner orbits, the ridge between them very blunt in its lower half, with a fine impressed line in its upper half. Clypeus broadly pyriform, about as wide as long, very slightly convex throughout; its anterior, free portion as long as the upper, interocular part; its truncate apex about one-fifth of the maximum width of the clypeus, with a slight inward curve preceded by a narrow, shiny, somewhat depressed area; the lateral angles hardly projecting, very blunt and somewhat raised longitudinally. Antennæ short; the flagellum gradually swollen from the base to the apical third; scape very slender, about half the length of the flagellum, distinctly curved; third antennal segment about one and one-half times the length of the fourth; fourth and fifth slightly longer than wide; sixth and seventh almost square; eighth to eleventh slightly wider than long; twelfth about as long as wide at the base. Mandibles much shorter than the length of the eye, straight; the apex blunt and slightly curved; the inner margin with three very superficial notches separating broad, low, blunt teeth. Thorax barrel-shaped, almost equally narrowed anteriorly and posteriorly, about one and one-half times as long as its greatest width and about as high as wide. Pronotum slightly narrowed toward the anterior margin which has a slight outward curve and is carinate; on the sides the carina is sharp and runs from the humeral angles to the coxæ; dorsally it is much finer, but is continuous across the middle; the smooth, anterior face with a pair of small, deep pits in the middle; humeral angles barely indicated, obtusely rounded. Mesonotum a little longer than wide, pentagonal in outline with the anterior third produced, slightly convex, with short traces of parapsidal furrows in front of the scutellum and with a fine raised line in the anterior third. Tegulæ about as wide as long, with broadly rounded outer margin, of normal shape; post-tegulæ narrow, finger-shaped, flat. Scutellum rectangular, one and one-third times as wide as long, flattened throughout, with an extremely fine, longitudinal, impressed line, without tubercles or carina; the deep suture separating it from the mesonotum finely foveolate. Postscutellum transversely elliptical, less than half as long as the scutellum, moderately convex throughout, somewhat sloping posteriorly, without ridges, tubercles or depressions. Mesepisternum completely divided into an upper and a lower plate; with a distinct prepectal carina beginning a little above the mesepisternal suture and extending to near the base of the middle coxæ. Propodeum moderately long, squarely and vertically truncate behind, hardly swollen on the sides; dorsal areas touching each other in the middle in a depressed horizontal area which is but little shorter than the postscutellum and separates it completely from the concavity; concavity wide, shallowly depressed, divided by a fine longitudinal carina which does not reach its upper edge; superior, lateral, and inferior ridges bluntly angular but not carinate; lateral angles broadly rounded. Abdomen elongate, moder-

ately slender. First tergite short, transverse, in outline cup-shaped with rounded sides, about one and one-half times as wide as long; its horizontal face, in profile, more than half the length of the second tergite; its anterior slope not forming an angle with the posterior, horizontal portion; the two areas not separated by a suture or carina; the horizontal area slightly wider in the middle than on the sides, without median depression; the hind margin hardly thickened, not produced in the middle, covering the depressed base of the second tergite; its extreme edge narrowly translucent and somewhat jagged. Second segment broadly barrel-shaped, somewhat more narrowed anteriorly than posteriorly, a little wider than long, moderately and about equally convex dorsally and ventrally; the apical margin simple, without raised or depressed lamella, the extreme edge narrowly translucent; the sternite gradually sloping and broadly rounded basally, slightly depressed medially, but without a longitudinal furrow, with a row of pronounced longitudinal riblets in the transverse furrow behind the basal articulation. No mite chamber is formed by the depressed basal neck of the second tergite. Legs slender, of normal shape. Wings with the usual type of venation; radial cell gradually and moderately widened opposite the second cubital, broadly rounded at the apex, with the stump of an appendiculate vein; third cubital much higher than long.

Head and thorax densely covered with medium-sized punctures, which are larger on the pronotum and mesonotum, smaller on the frons, and much finer on the mesopleura. Anterior face of mesopleura, sternum, metapleura, and tegulae impunctate. Punctures of the clypeus a little finer than those of the frons, but much more widely spaced, and separated by very faint, superficial, and irregular, longitudinal striae. Dorsal areas of propodeum rugoso-reticulate; lateral areas with fine, scattered punctures in the lower part, more heavily punctate toward the lateral ridge; concavity irregularly rugulose and with scattered, medium-sized punctures. Horizontal face of first tergite densely and fairly uniformly covered with medium-sized punctures which are distinctly larger and more irregular in the anterior part. Second tergite uniformly covered with fine, moderately dense puncturation; that of the second sternite and following segments much finer. Body shiny, with a few very short, grayish hairs on head and thorax.

Black. Base and under side of scape, apex of mandibles, most of the legs, most of the first abdominal segment, and an ill-defined, small spot on each side of the second tergite (far removed from the base), ferruginous to red. Basal third of the clypeus, a spot on the base of the mandibles, a triangular, median spot on the frons above the insertion of the antennae, a small spot in the sinus of the eye, a narrow stripe in the upper half of the cheeks close to the orbits, four small spots on the pronotum (one on each humeral angle and one on each side of the middle line, but removed from the anterior and posterior margins), the postscutellum, most of the upper plate of the mesepisternum, tegulae (except the ferruginous center) and post-tegulae, the hind margin of the first tergite (widest in the middle and gradually narrowed to the

sides), the broad uniform hind margin of the second tergite, the apical corners of the second sternite, and indistinct spots at the apex of the femora and at the base of the tibiae, pale sulphur yellow. There is a trace of a yellow dot in the ferruginous lateral spots of the second tergite.

Male unknown.

Specimen examined.—Bermuda, one female, holotype, September 1925 (L. Ogilvie.—Imperial Bureau of Entomology).

This specimen bears a female Strepsipteron protruding on the right side under the fourth abdominal tergite.

I have carefully compared this wasp with a large number of North American species of the subgenus *Stenodynerus*. It appears to differ structurally from all those that have been described thus far. The shallowly depressed interocellar area, the shape and sculpture of the clypeus, propodeum, and first and second tergites, the flat, simple apical margin of the second tergite, and the absence of a mite chamber, furnish the best characters. A species from Georgia, apparently undescribed, in my collection, comes nearest to *O. bermudensis*, but it is larger and is much more coarsely punctured on the first tergite of the abdomen.

I must provisionally regard *O. bermudensis* as an autochthonous member of the Bermudan fauna, evolved from a migrant from North America that reached the island by natural means.

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BOOK NOTICE.

INSECTS, TICKS, MITES AND VENOMOUS ANIMALS OF
MEDICAL AND VETERINARY IMPORTANCE, by W. S.
Patton and Alwen M. Evans.

This work must be considered a successor to the very comprehensive text book on *Medical Entomology* by Patton and Cragg, which is said to be out of print. The present work, amply illustrated and beautifully printed, is arranged especially for class use and consists of exercises for twenty-eight lectures and laboratory periods with elaborate discussion of the material used for demonstration and reference to methods of preparation for the different species. It is particularly full in descriptions and figures of the morphological details concerned with the attacks of the species on their hosts and those used in identification, with considerable attention to life history and habits. For students outside of the School of Tropical Medicine the absence of any bibliographical references will be regretted. The book is available directly from the authors and the following announcement by Dr. Patton should be carefully noted:

"As it is the only practical book on the subject, the writer is strongly of the opinion that its price should be within the reach of all to whom it may be of use. Had it been published in the usual way, its price would have been prohibitive to most medical officers and nearly all students of entomology. Under the circumstances, it can only be obtained from the Entomological Department, Liverpool School of Tropical Medicine, and would-be purchasers will therefore only waste time by applying to booksellers, who will themselves have to obtain it from the above source. Any number of copies can be sent, and it will be just as easy, if not easier, to obtain it in this way as from a bookseller. The price, £-20-., includes packing and postage to any part of the world. All copies going to the United States will contain an invoice for Customs purposes. The duty will bring the price to about \$5.00."

Apply with remittance to Miss M. Brown, Department Entomology, Liverpool School of Tropical Medicine, Pembroke Place, Liverpool, England.

HERBERT OSBORN.

A SYNOPSIS OF THE AMERICAN ARACHNIDS OF THE PRIMITIVE ORDER RICINULEI.

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Ricinulids are peculiar looking arachnids which resemble superficially spiders, but are readily distinguished from the latter since they have a segmented abdomen and are without eyes. They constitute the rarest order of all the arthropods in number of specimens taken and in number of locality records obtained. Although the group is represented by well preserved carboniferous fossil forms in the North Temperate Zone, the only living examples of this order have been taken from the tropics, and in the past from two restricted areas. One of these is along the central west coast of Africa and the other is in the upper Amazon region.

But few Ricinulids have ever been collected. The first species to be taken was *Cryptostemma westermanni* Guérin. It was described in 1838 from a specimen collected by Westermann along the coast of Guinea. Many years passed after this date before another record was made. It was Bates who discovered the second species on his voyage in the Amazon Basin. This species was described by Westwood in 1874 as *Cryptocellus fædus*. Other specimens subsequently were collected, yet when Hansen and Sørensen published their synopsis of this group in 1904 only a very few examples were available for study. They state: "As far as the number of species of Ricinulei is concerned we have consequently had much more ample material at our disposal than our predecessors, none of whom knew more than one species; but, as regards specimens, we have not been so well situated * * * because of five only out of our eight species have we had more than one specimen before us. Nor have we had any opportunity of dissecting more than one specimen, an example of *Cryptostemma crassipalpe*, for which we are indebted to the kindness of Professor C. Aurivillius." Although fossil Ricinulids have been described from the New World since Bates took his specimen in the basin of the Amazon, only one other specimen of a living

species has been taken. This one proved to be new and was described by Hansen and Sørensen as *Cryptocellus simonis* in 1904. It too was taken from the Amazon Basin.

The primitive nature of Ricinulids is indicated by their mouth-parts, their sternal characters, and the segmentation of the abdomen. Yet they stand alone among all of the more generalized arachnids in having the pedipalps immovably fused at their bases. In the Ricinulids there are certain peculiar and outstanding structures that are not properly understood at present. A very large, movable hood, the *cucullus* (Pl. III, Figs. 4 and 5), is suspended from the front margin of the cephalothorax in a vertical position. When this hood is closed the chelicerae (Pl. III, Fig. 6) are completely hidden. The fact that this structure is provided with muscles led Hansen and Sørensen to believe that it represented a true body segment.

In males there is a peculiar modification of the third pair of legs. The basitarsus and tarsus of each are swollen, guttered and modified in a manner very suggestive of the way the palpi of certain male spiders are modified. Other peculiar structures occur, but the discussion of these shall be left for a further communication which the writer hopes to present dealing with the morphology of Ricinulids.

The present paper has been made possible only on account of the expert skill of two of our best American collectors of arthropods, Dr. W. M. Mann, now Director of the National Zoological Park and Mr. H. S. Barber, of the Bureau of Entomology. Dr. Mann collected four specimens of Ricinulids, representing as many species and coming from three Neotropical countries. Mr. Barber furnished the writer with six specimens, all belonging to the same species, and all taken at the same time, and in the same place in Guatemala.

THE PROPER FAMILY NAME FOR THE RICINULIDS.

Hansen and Sørensen (1904) in their excellent paper on the Ricinulei used the family name of Cryptostemmatoidæ for the two included genera of living species. In doing so they followed Westwood (1874) who first established the family, using a name based upon that of the oldest genus, *Cryptostemma* Guérin (1838).

According to McAtee and Malloch (1925) *Cryptostemma* Guérin is antedated by *Cryptostemma* Herrich-Schäffer. Herrich-

Schaffer used the name for a genus of Hemiptera, the genus being the type for the hemipterous family Cryptostemmatidæ. McAtee and Malloch claim that Dr. E. Bergroth has confirmed the date of publication (1835) of *Cryptostemma* Herrich-Schäffer. They state that "Haliday thus was mistaken about the name being preoccupied by *Cryptostemma* Guérin (Arachnida) which was published in 1838."

Scudder (1885) established the family Poliocheridæ for his new genus *Poliochera*, of the same date which was based on a Palaeozoic fossil species. Other fossil species have been added to this genus, and further study of it has shown that it is closely related to the two genera of living species. Hansen and Sorensen (1904), therefore, have rightly considered the family Poliocheridæ as a synonym of Cryptostemmatoidæ.

Petrunkévitch (1913) proposed a new family which he called Holotergidæ, for the genus *Curculioides* Buckland, the other genus of fossil species. Cockerell (1916) suggested that this name be changed because it is not based on any generic name. He proposed the name Curculioididæ in its place. *Curculioides* differs from the other genera of Ricinulids in that there are no transverse sutures visible on the dorsum. It should be remembered in connection with this character, however, that among our living species such sutures become less evident as individuals reach maturity. Also, in all species the whole abdominal tergum is entirely fused and rigid, being in fact about as thick between sclerites as elsewhere. Thus it would appear that the placing of *Curculioides* in a family by itself is hardly justified.

The rejection of the family name Cryptostemmatoidæ would make those of three different family names available for use. However, the practice of most taxonomists in always retaining the same genus for the type of the family, even although the name of this genus is shown to be preoccupied, appears to be logical. In this particular instance such a practice seems doubly important because a shifting of the type genus of the family means going from one of the living species to one of the Palaeozoic species.

In view of the fact that the order name Ricinulei is quite appropriate and has become well established, the writer first thought of using the name *Ricinulus* for the genus *Cryptostemma* Guérin, thus the name for the type genus, family and

order would all have the same stem. But, alas, the name *Ricinula* has already been used. However, *Ricinoides* appears to be unused and is available. Although not having the same stem as *Ricinulei* it is very suggestive of the latter name. The new family name, therefore, would be *Ricinoididæ*.

THE GENERA OF RICINOIDIDÆ.

The first genus to be established for a living species of these peculiar arachnids was *Cryptostemma* Guérin (1838), which name, being preoccupied as already stated, is here supplanted by *Ricinoides*.

Westwood (1874) established the second genus, *Cryptocellus*, for his American species *foedus*. This genus Hansen and Sørensen (1904) recognized and placed in it the second American species, *simonis* Hansen and Sørensen. Although the American and Old World species are placed in separate genera these are in fact remarkably alike. However, Hansen and Sørensen found two characters by which the then known species of *Cryptocellus* could be separated from those of *Cryptostemma*. They are the absence of the smaller apical process of the first segment of the chelicera and the much greater length of the fifth tarsal segment of leg II in proportion to the fourth. I find that these characters hold good for the four new species that are added in this paper to the genus *Cryptocellus*. In fact the differences in the ratio of the fifth to the fourth tarsal segment of leg II is even more accentuated in these new American species than in the old ones.

Fossil *Ricinulids* are also much like the living ones, although they have rightly been placed in different genera. However, the characters that have been used for these genera need a new appraisal. The first genus established for these extinct species was *Curculioides* Buckland (1837), erected a year before Guérin's genus, which was established for the first discovered living species.

Curculioides differs from all the other genera of *Ricinulids*, living or extinct, in having no evident transverse sutures to the dorsum of the abdomen. All four segments of the abdomen proper appear to be fused dorsally.

Scudder (1885) established the genus *Polyochera* for his *punctulata*, a fossil species taken at Mazon Creek, Illinois. His description follows:

"Cephalothorax scarcely longer than broad, slightly narrowing anteriorly, the front square. Legs stout, moderately long. Abdomen full, at base as broad as the cephalothorax, broadening slightly behind, fully rounded, the first segment about one-third the length of the others, which are equal."

Although this description may have been sufficient when it was published to differentiate a fossil genus, unfortunately everything that is said in describing it might equally apply to every known living species.

Petrunkévitch (1913) restudied the type of Scudder's *punctulata*, which is now in the United States National Museum (No. 37971), and he published both figures and photographs of the same. This author considered the genus good and bases his conclusions on the characters of the second leg. This leg has been represented as being composed of only three segments beyond the femur and to be terminated with a pair of claws. In other words this part of the leg is supposed to be composed of a normal patella, a short tibia and a very short, fused basitarsus and tarsus. Our living specimens have this part of the leg composed of a patella, a long tibia, a long basitarsus and a long five-segmented tarsus. Furthermore, in all the living Ricinulids the second legs are much the longest of all pairs. As Scudder's type has been interpreted, this pair is supposed to be much shorter than either the third or fourth pair.

In order to get further evidence upon the nature of the segmentation of leg II of fossil forms the writer worked out the second leg of a specimen of *Curculioides ansticii* Buckland. The patella and the more proximal segments were already exposed and distinct, and by removing the overlaid material the full length of the tibia was revealed, very definitely stained brown by iron deposit. Using this preparation for comparison with the type of Scudder's *punctulata*, it could be seen that what had been considered as tibia and fused basitarsus (metatarsus) and tarsus was in reality one segment, the tibia. There is a suture-like structure in this part of the leg of Scudder's type, but an examination of it under the binocular microscope shows that it only represents what was a crack in the integument of the fossil specimen.

But how about the claws at the end of leg II in Scudder's type? There is a curved line impressed in the clay ironstone

that is quite suggestive of the imprint of a claw or claws. But do they really represent impressions of these structures? The writer is of the opinion that they do not for two reasons:

(1). They do not occur at the right place in the leg, counting the segments from the base toward the tip.

(2). Tarsal claws are unknown in all of the known Palaeozoic spider fossils, of which there is a large number of specimens. In all of these not a single tarsus has been found terminated with claws.

If we reject, then, the characters of the legs as given for *Polyochera*, what is to become of the genus? Fortunately the coxæ give us good generic characters. In this genus, and also in *Curculioides*, the second pair of coxæ are short and triangular and are separated from each other mesially. In our living Ricinulids these coxæ are similar to those of the third pair, being long and broadly matching each other on the median line.

The four genera of Ricinoididæ may be separated by means of a key as follows:

KEY TO THE GENERA OF LIVING AND EXTINCT RICINULEI.

- A. Second coxæ subtriangular and not meeting on median line,
 - B. Dorsum of abdomen divided into distinct tergites by transverse sutures..... Palaeozoic genera *Polyochera* Scudder.
 - BB. Dorsum of abdomen without transverse sutures, *Curculioides* Buckland.
- AA. Second coxæ broad, platelike and coming together on the median line. Recent genera, represented only by living species.
 - B. Movable digit of chelicera apposed by a large and a small fixed digit; fourth segment of tarsus II longer than fifth. Ethiopian species..... (Cryptostemma Guérin). *Ricinoides*, new name.
 - BB. Movable digit of chelicera apposed by a single, large, fixed digit; fourth segment of tarsus II shorter than fifth. Neotropical species..... *Cryptocellus* Westwood.

The Genus *Cryptocellus* Westwood.

All of our living American Ricinulids go into the genus *Cryptocellus* Westwood. It is unfortunate that in no single instance have both sexes been collected of a single one of the included species; yet the writer has on hand no less than seven specimens of one species. The characters of this genus have already been given.

KEY TO THE SPECIES OF *CRYPTOCELLUS*.

(The Living American Species of Ricinulei).

- A. Length of body over 7.5 mm.; integument with but few tubercles, but provided with pits. *C. magnus*, new species.
- AA. Length of body less than 6 mm.; integument tuberculate.
 - B. Last segment of tarsus II equal in length to all the other segments, ... *C. manni*, new species.
 - BB. Last segment of tarsus II not longer than third and fourth together.
 - C. Movable digit of chelicera with a much enlarged tooth near the base of the row. Not reported from Brazil.
 - D. Upper posterior margin of first postabdominal segment deeply notched on median line, ... *C. emarginatus*, new species.
 - DD. Upper posterior margin of first postabdominal segment not notched *C. barberi*, new species.
 - CC. Movable digit of chelicera without such a tooth. Brazilian species.
 - D. Hood but slightly broader than long, and scarcely lobed ventrally *C. foedus* Westwood.
 - DD. Hood about one and a half times as broad as long, and distinctly lobed ventrally, ... *C. simonis* Hansen & Sørensen.

DESCRIPTIONS OF SPECIES.

Technical descriptions are here given for four new species. No complete descriptions can be given for the two that have been previously distributed. However, notes have been taken concerning them from the excellent synopsis of Hansen and Sørensen (1904). It should be stated that each of these two species is represented by a single specimen.

***Cryptocellus magnus*, new species.**

(Plate I).

FEMALE.

Cephalothorax longer than broad and irregularly clothed with scant pubescence above. Integument pitted instead of being tuberculate. Above each coxa II on each side of the cephalothorax is a lighter, outwardly convex area, simulating the cornea of an eye.

Hood considerably broader than long, swollen distally and clothed in front with fine hair-like setæ.

Chelicerae completely hidden in the single dry-mounted specimen.

Pedipalps reddish brown, much lighter in color than the body. First, or fixed, segment of pedipalps plate-like; second very short, swollen distally; third broader than long and longest along front aspect; fourth about three times as long as third and curving backward very strongly along its distal half; fifth almost as long as the second, third and fourth combined and terminated by a short, fixed claw; sixth segment, or claw, longer than fixed claw of fifth segment.

First pair of legs the shortest of all pairs; coxa triangular and not meeting its fellow on the median line; trochanter as broad as long; femur over twice as long as trochanter and excavated below on its distal half; patella but slightly longer than broad and somewhat pedicellate; tibia one and a half times as long as patella and excavated ventrally on its distal two-thirds; basitarsus slightly longer than tibia, curved upward and with a few tubercles on upper surface; tarsus but slightly longer than broad, swollen.

Second pair of legs the longest, sharply bent, or kneed, at the junction of femur with patella; basitarsus curved upward, as long as tarsus; five-segmented tarsus with last segment equal in length to second, third and fourth put together. The second pair of legs has some spine-like tubercles, chiefly on the ventral surfaces.

Third pair of legs slightly shorter than the fourth; the two trochanters subequal; tibia and basitarsus of about equal length.

Fourth pair of legs next to second in length but much shorter than this pair; two trochanters subequal; tibia and basitarsus of about equal length, the former excavated below for almost its entire length.

Abdomen proper almost black, more or less sparsely clothed with minute, hair-like setæ and without tubercles, but instead provided with pits. There is a very definite row of these pits on the dorsum along the suture between the first and second visible tergites, also a row of smaller pits laterally, parallel to the lateral margins of the body on the second and third visible tergites.

Postabdomen represented by the last three abdominal segments, its second segment being completely contained by the first, and the third by the second. First, or outer, segment as broad as long, swollen, and with an even posterior border. No comb of teeth on second segment.

Total length of body in natural position, 7.80 mm.; length of cephalothorax, 2.20 mm., width, 2.10 mm.; length of abdomen exclusive of postabdomen, 5.10 mm., width, 3.10 mm.

Type locality. Cincinatti, Colombia.

Type. Cat. No. 955, U. S. N. M.

Described from a single female collected at type locality, 1924, by Dr. W. M. Mann. Although this species is much smaller than some of the fossil forms, it is much larger than any of the other living American species. Not only is *magnus* very distinct among the American Ricinulids on account of its size but also because of the paucity of tubercles on the integument, there being but few of these, which are confined almost exclusively to the under surfaces of the legs. Also this species is peculiar in having pits on the dorsal surface of the body. These may be regarded, in a way, as taking the place of the tubercles.

Cryptocellus manni, new species.

(Plate II, Fig. 2; Plate III, Fig. 5).

FEMALE.

Cephalothorax of about equal length and breadth, being broadest near the posterior margin. It is adorned dorsally with groups of tubercles (Pl. II, Fig. 2) and clothed with fine hair-like setæ. Dorsal tubercles grouped as follows: There is a band of tubercles along the posterior margin, an irregular row of tubercle groups along the median line, an irregular row of tubercle groups along each lateral margin, and between these some irregularly placed groups in the posterior two-thirds of cephalothoracic area.

Hood (Pl. III, Fig. 5) considerably broader than long and very slightly lobed; clothed with short, hair-like setæ and basal half adorned with flattened, circular tubercles that are grouped laterally and along the median line.

Chelicerae powerful, the movable arm surpassing the fixed one and provided with six teeth, the basal one of which is much larger than the others; fixed arm with distal tooth much the largest.

Pedipalps of usual shape; basal segment well studded with tubercles; each of the other segments with a few tubercles. Movable arm of pincers with about a dozen very low oval teeth; fixed arm with 6-7 larger teeth, the most proximal being the largest and almost square in outline.

First pair of legs the shortest, reaching to about the middle of the tibiae of second legs; basitarsus curved; tarsus scarcely half as long as basitarsus and much swollen dorsally.

Second pair of legs almost twice as long as the first pair; coxa not narrowed toward median line and with a row of tubercles around its anterior, inner and posterior margins; femur and basitarsus curved; tarsus about equal to basitarsus, each successive segment of the same being longer than its proximal predecessor and the last being equal to the first four.

Third legs longer than the first or fourth; coxa wedge-shaped, its width proximally being equal to about one-half the width at distal end; anterior, inner and posterior borders of coxa with a row of tubercles; tarsus slightly longer than basitarsus, last segment being the longest and swollen.

Fourth legs between the first and third in length; coxa similar to coxa of leg III, but shorter and broader; tarsus fully as long as basitarsus and with its distal segment the longest and swollen.

Abdomen proper with tergites well separated and provided with groups of tubercles which are grouped largely about the margins. Most of these groups are circular in shape. In addition to these tubercles the abdomen is well provided with short setæ.

Postabdomen as broad as long, the second segment being contained in the first and the third in the second. The second postabdominal segment bears a comb of four flattened, subspatulate setæ. These setæ are so broad that they almost touch each other.

Total length of body in natural position, 4.95 mm.; length of hood, 0.93 mm., width, 1.27 mm., length of cephalothorax, 1.30 mm., width, 1.10 mm.; length of abdomen exclusive of postabdomen, 3.50 mm., width, 2.40 mm.; length of first segment of postabdomen, 0.50 mm., width, 0.52 mm.

Type locality. Cincinatti, Colombia.

Type. Cat. No. 996, U. S. N. M.

Described from a single female taken at the type locality, February, 1924, by Dr. W. M. Mann, for whom the species is named. Two of the other species described in this paper have the postabdominal comb, but in them the spines are not flattened as they are in *manni*. This species is distinct, also, in the manner of distribution of the tubercles on the integument.

***Cryptocellus emarginatus*, new species.**

(Plate III, Fig. 7).

Cephalothorax almost as broad as long, completely studded above with round tubercles and sparsely invested with short, inconspicuous setæ.

Hood much broader than long, entirely studded above with tubercles and clothed with hair-like setæ of varying lengths. It is not lobed.

Chelicera stout; movable arm sickle-shaped, with 8-10 teeth, no one of which is markedly larger than any of the others; fixed arm doubly curved, distal half being toothless, while basal half bears four teeth, the most distal being the largest.

Pedipalps of the usual shape; first, or fixed, segment broader than long, with its inner half studded with tubercles; pincers at distal end rather sharp; movable arm more strongly curved about its middle than elsewhere, inner margin with minute sharp teeth, more numerous toward the base; fixed arm with 4-5 much larger teeth.

First pair of legs reaching to about the middle of the tibiae of the second pair; coxa long and wedge-shaped and studded with tubercles; tibia swollen toward its base, shorter than basitarsus; basitarsus curved, well studded with short, spine-like tubercles dorsally; tarsus very short, subglobular.

Second pair of legs much the longest, as usual; coxa long for its width, broadest near distal end, posterior border broadly emarginate, most of tubercles arranged on the margins; trochanter slightly longer than broad, but broader than femur; basitarsus almost straight, longer than tarsus and studded with spine-like tubercles; tarsus with each succeeding segment longer than the preceding, the last one being shorter, however, than the third and fourth taken together.

Third pair of legs reaching beyond the base of basitarsus; coxa strongly outwardly curved along front margin near the distal end, with tubercles arranged chiefly along the margins; basitarsus and tarsus subequal, the last segment of the latter swollen and peculiar in being diamond-shaped, (Plate III, Fig. 7).

Fourth pair of legs about as long as third pair; coxa about as long as coxa of third legs and studded with tubercles in much the same way; basitarsus longer than tarsus; last segment of tarsus swollen.

Abdomen proper oval, all tergites fairly evenly studded with tubercles; central section of tergite of second visible segment produced at anterior corners; lateral sections of first tergite small, almost circular.

Postabdomen about as broad as long and with segments arranged in their usual positions; first segment much swollen toward its base and deeply notched on its posterior border at the upper median line; second segment long and narrow, being almost twice as long as wide, and less than half as wide as first segment, with comb of four spines; third segment very small, less than half as long as second segment and about half as wide.

Total length of body in natural position, 3.85 mm.; length of hood, 0.51 mm., width, 0.83 mm.; length of cephalothorax, 1.45 mm., width, 1.33 mm.; length of abdomen exclusive of postabdomen, 2.40 mm., width, 2.20 mm.; length of first segment of postabdomen, 0.46 mm., width, 0.40 mm.

Type locality. Navarro Farms, Costa Rica.

Type. Cat. No. 997, U. S. N. M.

Described from a single specimen (adult female?) taken at type locality, March 19, 1924, by Dr. W. M. Mann. This species is distinct in the shape of the last segment of tarsus III and in having the tubercles distributed over practically all the sclerites of the body.

***Cryptocellus barberi*, new species.**

(Plate II, Fig. 3; Plate III, Figs. 4, 6).

FEMALE.

Cephalothorax distinctly longer than broad, front margin about straight, posterior margin outwardly rounded. Above, the cephalothorax is completely studded with circular tubercles and clothed sparingly with short, hair-like setæ.

Hood (Pl. III, Fig. 4) very much broader than long, clothed with hair-like setæ of varying lengths and provided on each side at the base with a cluster of low, cylindrical tubercles.

Chelicera (Pl. III, Fig. 6) stout; movable arm surpassing fixed one, provided with 6-7 teeth, the second one from the base being the largest; fixed arm strongly curved distally and provided with 5-6 teeth, the distal one being much the largest; setæ on chelicera long, straight and minutely pectinate.

Pedipalps rather slender; basal segment considerably longer than broad and with inner half studded with tubercles; second segment slightly longer than broad; third segment longer than usual and somewhat pedicellate; pincers small, movable arm almost twice as long as fixed one, both arms with small teeth.

First pair of legs reaching almost to the tip of tibia of second pair; coxa triangular and studded with tubercles; tibia straight, much longer than patella; basitarsus shorter than tibia; tarsus about three-fourths as long as basitarsus.

Second pair of legs of usual length; coxa very broad and of about the same width throughout, studded with tubercles except for a middle area; trochanter very slightly broader than femur; basitarsus about equal to tibia and studded throughout with tubercles; tarsus longer than basitarsus, its last segment being almost equal to segments 3 plus 4.

Third pair of legs about equal to fourth; coxa wedge-shape and with most of the tubercles arranged along the margins; tibia much longer than patella, slightly swollen; basitarsus slightly curved, equal to tibia; tarsus slightly longer than basitarsus, third segment the shortest, fourth the longest.

Fourth pair of legs the weakest; coxa broader and shorter than coxa III; each trochanter longer than broad; femur about straight; patella short and swollen; tibia stout and straight; basitarsus equal to tibia in length but more slender; tarsus slightly longer than basitarsus, its distal segment being almost equal to third and fourth taken together.

Abdomen proper (Pl. II, Fig. 3) with strongly rounded sides, the outer margins of the lateral plates being rounded to conform to lateral margins. Tergal plates studded with tubercles as shown in Figure 3, Plate II.

Postabdomen about as broad as long and strongly swollen in the middle; outer, or first, segment with basal half studded with tubercles, posterior border not emarginate dorsally; second segment less than half as broad as the first and with comb of four peg-like setae; third segment cone-shaped, almost as broad as long.

Total length of body in natural position, 4.50 mm.; length of hood, 0.47 mm., width, 0.76 mm.; length of cephalothorax, 1.47 mm., width, 1.30 mm.; length of abdomen exclusive of postabdomen, 2.80 mm., width, 1.70 mm.; length of first segment of postabdomen, 0.43 mm., width, 0.40 mm.

Type locality. Near Livingston, Guatemala.

Type. Cat. No. 998, U. S. N. M.

Described from seven specimens, including an adult female taken at La Ceiba, Honduras, 1920, by W. M. Mann, and six individuals taken at type locality by H. S. Barber. The individuals taken by Mr. Barber, for whom the species is named, include adult females and nymphs and were taken, according to him, "In leaf litter on steep talus between limestone cliff and Rio Dulce, about three miles from Livingston, Guatemala, May, 1906." Mr. Barber states that the individuals moved about slowly and were all taken in an area of a few square yards.

The specimens from Guatemala are in an excellent state of preservation, notwithstanding the fact that they were taken over twenty years ago. This will allow work to be done on the internal anatomy of these arachnids, concerning which nothing is known. In fact the writer has already sacrificed one individual and has learned something of the nervous and digestive systems.

There is a very large central nerve mass or brain located ventrally in the anterior region of the cephalothorax, and this central ganglion sends large nerves to the chelicerae and legs and smaller ones to certain other structures.

A feature of importance in regard to the digestive system is the great development of the liver sacs. These structures are by far the most conspicuous of any in the abdomen. They are caeca of large diameter and with granular cells and fill up most of the space above and to the sides of the almost straight alimentary canal.

The gut proper enlarges into sac-like proportions in front of the small rectum. The latter passes directly through the last segment of the small postabdomen and empties through a slit-like, chitin-rimmed anus at the tip. Hansen and Sørensen (1904) are quite right in stating that the anus is situated at the end of the inner (last) segment of the postabdomen. The anal slit, in fact, may be seen in undissected specimens by viewing the postabdomen directly from behind in strong light with the binocular microscope. The morphology of this species will be worked out at some future date. It was thought proper to add this much in giving notes on our only American species of *Ricinulei* that is known from more than one specimen.

***Cryptocellus foedus* Westwood.**

FEMALE.

This species described by Westwood in 1874 is known only from a single female. The specimen was collected by Bates (1861) in the Province of Amazonas, Brazil. Hansen and Sørensen (1904) have given a good description of it accompanied by excellent figures. From their work it is learned that this species is very much like *C. barberi*, new species, but differs from *barberi* in a number of respects. In *foedus* there is no enlarged tooth at the base of the row on the movable arm of the chelicera; in *foedus* the hood is slightly bilobed and studded

over most of its external surface with tubercles, while in *barberi* there is no indication of the hood being bilobed, and the tubercles are all confined to the upper corners; in *foedus* the tergal plates of the abdomen are about evenly studded with tubercles, while this is not true of *barberi*.

The measurements given for *foedus* by Hansen and Sørensen follow:

"Length of body, 4.9 mm.; length and width of cephalothorax, 2.0 mm.; length of abdomen, 3 mm.; palpi, 3.7 mm.; legs, I, 4.6 mm.; II, 7.7 mm.; III, 5.2 mm.; IV, 5.5 mm."

The species is said to be black above and fuscus ferrugineous below; dorsum of body densely and finely granular; and the cucullus to be a little longer than its width at the base.

Cryptocellus simonis Hansen and Sørensen.

MALE.

The single male specimen upon which the description of this species is based is the only male Ricinulid to be taken in the New World. Fortunately for science it has been well described by Hansen and Sørensen and excellently figured by Hansen. *C. simonis* was taken in the same upper Amazon region that *C. foedus* came from, and is a species apparently most closely related to *foedus*. Unfortunately, however, from the standpoint of comparison of the two, the same sex is not known for both of them.

C. simonis is said to differ from *foedus* particularly in the shape of the hood, or cucullus. The hood of *simonis* is, according to Hansen and Sørensen, broader in proportion to its length, is distinctly bilobed, and has fewer tubercles. In the specimen described the dorsal sclerites of the abdomen have grown almost together.

The modified third legs of the male are more extreme in their adaptation than in the African Ricinulids. The basitarsus constitutes a subspherical bulb with a rather large opening; the first segment of the tarsus is reduced posteriorly and in front expanded into a leaf-like process; the second segment of the tarsus is lengthened and expanded in front into a leaf-like process joined with that of the first segment; the last two tarsal segments are not modified.

The dimensions of *C. simonis* given by Hansen and Sørensen are:

"Length of body, 5.3 mm.; length of cephalothorax, 2.2 mm.; width of cephalothorax, 2.0 mm.; length of abdomen, 3.1 mm.; palpi, 3.2 mm.; legs, I, 5.4 mm.; II, 9 mm.; III, 5.8 mm.; IV, 6.3 mm."

The single specimen was taken in the Province of Amazonas, Brazil.

A LIST OF THE KNOWN SPECIES OF LIVING RICINULIDS, THEIR DISTRIBUTION AND THE NUMBER OF SPECIMENS TAKEN.

Ricinoides, new name.

- | | | |
|--|-------------------|--------------------|
| 1. <i>R. westermanni</i> (Guérin) | Togo | 1 ♂, 1 juv. |
| 2. <i>R. afzelii</i> (Thor) | Sierra Leone | 2 ♀'s. |
| 3. <i>R. karschi</i> (Hansen and Sørensen). | Kamerun and Congo | 2 ♂'s, 2 ♀'s. |
| 4. <i>R. crassipalpe</i> (Hansen and Sørensen) | Kamerun | 2 juv. |
| 5. <i>R. plebejum</i> (Hansen and Sørensen). | Togo | 1 juv. |
| 6. <i>R. sjostedti</i> (Hansen and Sørensen). | Kamerun | 6 (♂'s, ♀'s, juv.) |

Cryptocellus Westwood.

- | | | |
|--|------------------------|------------------|
| 1. <i>C. foedus</i> Westwood | Brazil | 1 ♀. |
| 2. <i>C. simonis</i> (Hansen and Sørensen) | Brazil | 1 ♂. |
| 3. <i>C. magnus</i> , new species | Colombia | 1 ♀. |
| 4. <i>C. manni</i> , new species | Colombia | 1 ♀. |
| 5. <i>C. emarginatus</i> , new species | Costa Rica | 1 (♀?). |
| 6. <i>C. barberi</i> , new species | Guatemala and Honduras | 7 (♀'s and juv.) |

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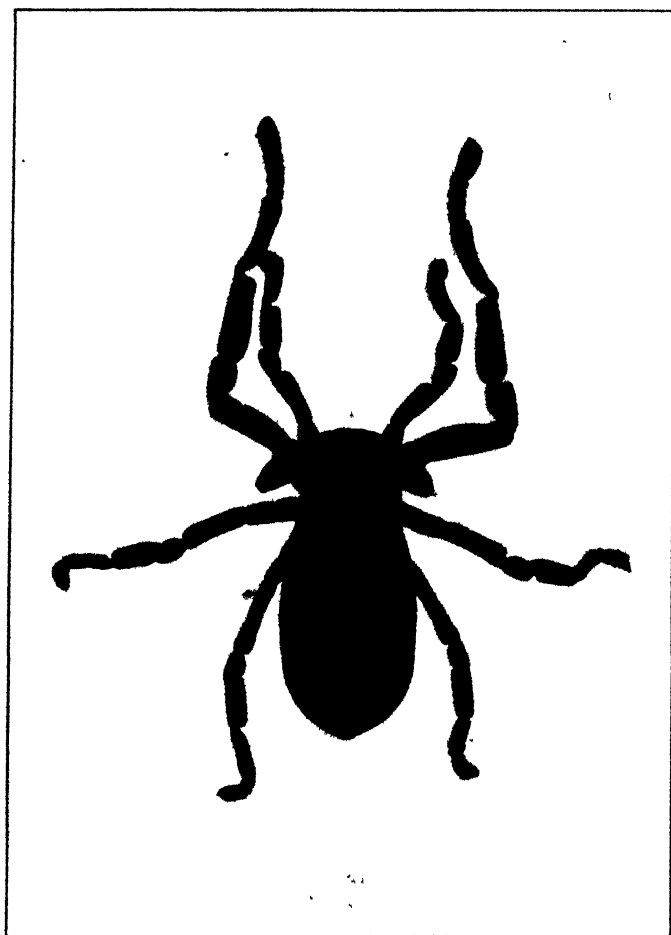
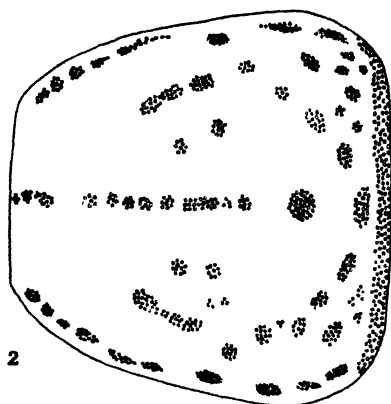


Fig. 1. *Cryptocellus magnus*, new species.
Dorsal view of female, $\times 5$.

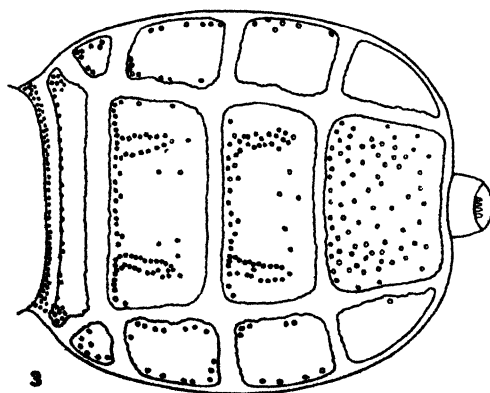
(Photograph by J. C. Pratt, of the Bureau of Entomology.)



2

Fig. 2. *Cryptocellus manni*, new species.

Dorsal view of cephalothorax (hood detached) showing arrangement of tubercles, but not showing setæ. $\times 38$.



3

Fig. 3. *Cryptocellus barberi*, new species.

Dorsal view of abdomen showing tergites and chitinous tubercles, but not showing setæ, $\times 38$.

(Drawings by H. E. Ewing.)

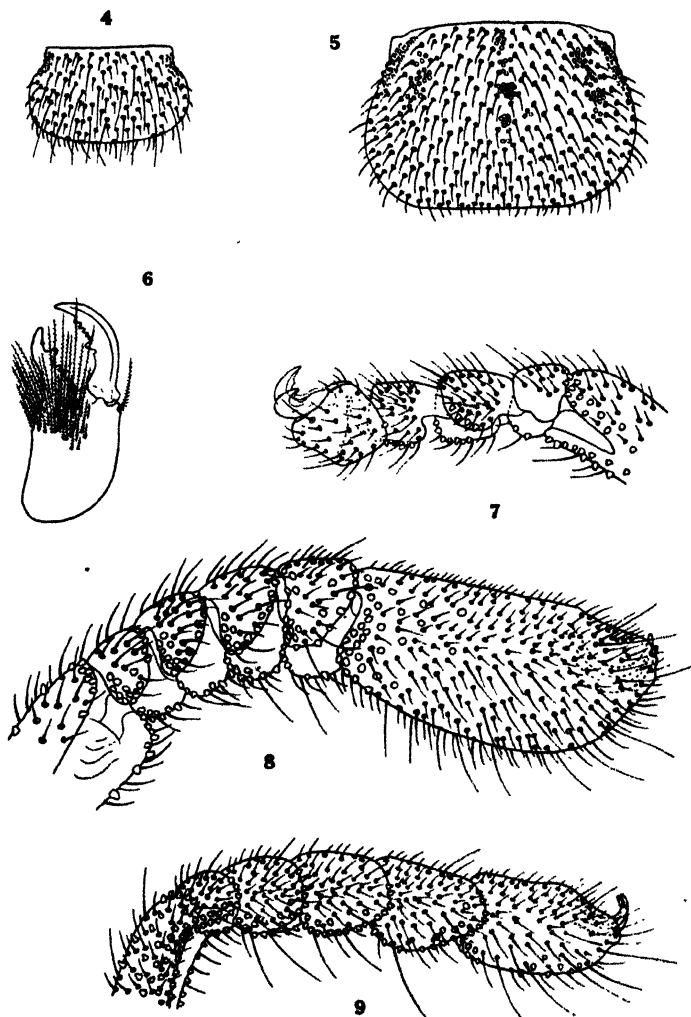


Fig. 4. *Cryptocellus barberi*, new species. Front view of hood, $\times 38$.

Fig. 5. *Cryptocellus manni*, new species. Front view of hood, $\times 38$.

Fig. 6. *Cryptocellus barberi*, new species. Ventral view of left chelicera, $\times 50$.

Fig. 7. *Cryptocellus emarginatus*, new species. Dorsal view of left tarsus III, $\times 50$.

Fig. 8. *Cryptocellus manni*, new species. Dorsal view of right tarsus II of female, $\times 50$.

Fig. 9. *Cryptocellus emarginatus*, new species. Dorsal view of right tarsus II of female, $\times 50$.

(Drawings by H. E. Ewing.)

ABSOLUTE HUMIDITY AS A FACTOR IN INSECT COLD HARDINESS WITH A NOTE ON THE EFFECT OF NUTRITION ON COLD HARDINESS

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Formerly National Research Fellow in Zoology, 1925-27

ABSTRACT.

In both eggs and larvæ of *Heemerocampa leucostigma* Smith and Abbot, cold hardiness can be expressed by the equation

$$T_1 = K \frac{1}{H_a}$$

where T_1 = survival temperature in degrees centigrade (or cold hardiness to the intensity factor).

H_a = absolute humidity in millimeters of vapor pressure.

K_0 = constant for eggs = 14

K_1 = constant for 1st instar larvæ = 41.8

K_2 = constant for 2nd instar larvæ = 37.4

K_3 = constant for 3rd instar larvæ = 34

Larvæ from cold hardy eggs tend to be more cold hardy than larvæ from non-cold hardy eggs. Larvæ of each succeeding stadium tend to be less cold hardy than the one preceding.

In the larvæ of the Japanese beetle, *Popillia japonica* Newman, absolute humidity is correlated with cold hardiness to the intensity factor of low temperature. The adult, although a summer stage, is more cold hardy than the 3rd instar larva, and the 3rd instar larva is more cold hardy than the first. Absolute humidity does not play as important a part in cold hardiness of the adult as for the larvæ. In the Japanese beetle larvæ starvation at first increases, later decreases cold hardiness. Type of food affects degree of cold hardiness.

INTRODUCTION.

The environmental factor of absolute humidity, or the total amount of atmospheric moisture present in the air at a given temperature has been little used in ecological work. The literature on the effects of relative humidity,

$$\frac{\text{moisture present in air}}{\text{moisture air can hold at a given temperature,}}$$

is voluminous. In general, low relative humidity in both plants and animals is associated with increased cold hardiness.

This paper is one of a number of studies by the author on factors associated with, or producing cold hardiness, especially in organisms exposed to low temperature extremes in their normal habitat. The eggs of the white marked tussock moth, *Hemerocampa leucostigma* Smith and Abbott, were studied in 1926-1927 and in 1927-1928. Eggs of this species can be obtained in large quantities, even in cities, where they occur on trees, telephone poles, and in the crevices of stone walls. From 150-700 eggs are laid in one cluster, which is generally covered by a coarse cocoon. The tussock moth over-winters in the egg stage.

The Japanese beetle over-winters in the larval stage, about 97% in the 3rd; about 3% in the 2nd instar. The adult appears from early summer till early fall, and in the vicinity of Philadelphia can be procured in large quantities.

TABLE I.
TEMPERATURE INSIDE AND OUTSIDE A TUSSOCK MOTH EGG COCOON.

Outside Cocoon	Inside Cocoon
25. °C.	24.9 °C.
20. °C.	20. °C.
12.5 °C.	12.5 °C.
10. °C.	10. °C.
5.6 °C.	5.6 °C.
4. °C.	4.1 °C.
0. °C.	0. °C.
-12. °C.	-12. °C.
-14. °C.	-14. °C.
-17. °C.	-17. °C.
-20. °C.	-20. °C.

COLD HARDINESS IN TUSSOCK MOTH EGGS.

At the end of the first year the survival temperature of 600 eggs had been tested. They exhibited no apparent periodicity. Their cold hardiness is not a linear function of temperature. At a given temperature cold hardiness was found to be correlated with relative humidity; the greater cold hardiness being associated with the lowest relative humidity. Work was continued on these eggs a second year, when over 1500 eggs were frozen, bringing the total number of determinations to 2100.

The amount of insulation offered by the cocoon covering tussock moth eggs was determined by inserting one thermo-

couple inside the cocoon and another outside the cocoon. There was no appreciable difference or lag between temperature inside and outside the cocoon. The results of a series of studies made to determine the insulating properties of cocoons are shown in Table I. Tussock moth eggs therefore form a group exposed to the extremes of the environmental temperature. Eggs were collected from September to June in 1926-1927 and 1927-1928.

Eggs were placed in small chambers in which the humidity was controlled by H_2SO_4 , according to the method of Baumberger (1914). Headlee's method (1917) of using super-saturated solutions of different salts was also used. Temperature

TABLE II.
EFFECT OF DEHYDRATION ON VIABILITY OF TUSOCK MOTH EGGS

Temperature	Relative Humidity	Number of Eggs Exposed	Number Hatched	Per cent Hatched
20°C.	100	250	215	86 7 $\frac{7}{10}$ %
	80	200	187	93 5 $\frac{5}{10}$ %
	50	200	99	49 5 $\frac{5}{10}$ %
10°C.	100	250	218	87 2 $\frac{2}{10}$ %
	80	300	276	92 2 $\frac{2}{10}$ %
	50	250	217	86 8 $\frac{8}{10}$ %
0°C.	100	250	203	81 2 $\frac{2}{10}$ %
	80	200	183	91 5 $\frac{5}{10}$ %
	50	200	160	80 $\frac{0}{10}$ %

was controlled within $\pm 1.0^\circ C$. The methods for controlling relative humidity have their limitations, especially in small chambers with very slow or very little circulation. However the methods gave comparable results which could be repeated.

Eggs from each cocoon were divided into two sets (1) for cold survival tests, and (2) as controls. Hatching was the final test of viability. After some experience it was possible to tell the condition of the egg even before hatching. Healthy eggs are firm, white and almost spherical. Eggs which do not hatch are somewhat darker and often have depressions in them. The effect of a series of temperatures and relative humidities on the hatchability of eggs is shown in Table II. Low relative humidity does not affect viability except at high

temperatures. At $+20^{\circ}\text{C}$. with 50% relative humidity about half the eggs hatched.

Generally eggs do not hatch when kept in a dry atmosphere except on subsequent soaking. All eggs in these experiments were soaked to facilitate hatching. Soaking introduces an additional factor, which is offset however by the hastened process of hatching, thus eliminating additional growth and time factors.

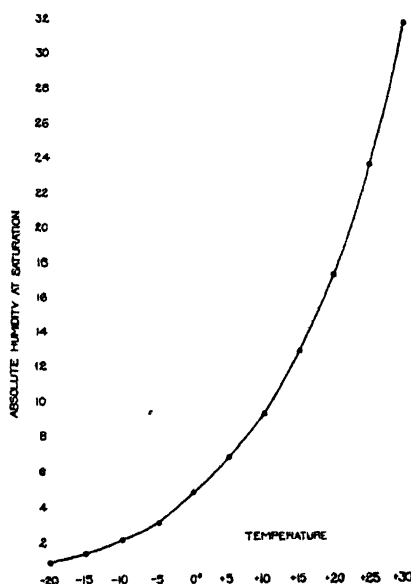


Fig. 1. Absolute humidity at saturation expressed in millimeters vapor pressure plotted against temperature in degrees centigrade.

As was stated above, ordinary eggs, kept at a low relative humidity do not hatch. Hatching of eggs that were dehydrated occurred once during the second years' work, when a lot of 100 eggs being dehydrated over CaCl_2 hatched. Fifty of these larvæ were tested for cold resistance, but none of them were able to withstand temperatures lower than -2°C . Both the eggs and larvæ of this lot were exceptional, for in all other cases eggs capable of resisting low humidities produced cold hardy larvæ. The CaCl_2 was tested and found to be in good condition, thus showing that the eggs had actually been exposed to dehydrating action. The only apparent explanation is that dehydration carried too far does not produce cold hardy larvæ.

Since temperature effect alone could not explain differences in cold hardiness between tussock moth eggs, and since their cold hardiness bore a relationship to both temperature and relative humidity, absolute humidity was thought to be the key to cold hardiness. Absolute humidity at saturation forms a logarithmic curve which rises slowly at low and very rapidly at high temperatures, (See Fig. 1). Similar curves are produced at other relative humidities than saturation. The cold hardiness of the 600 tussock moth eggs tested in 1926-1927, and

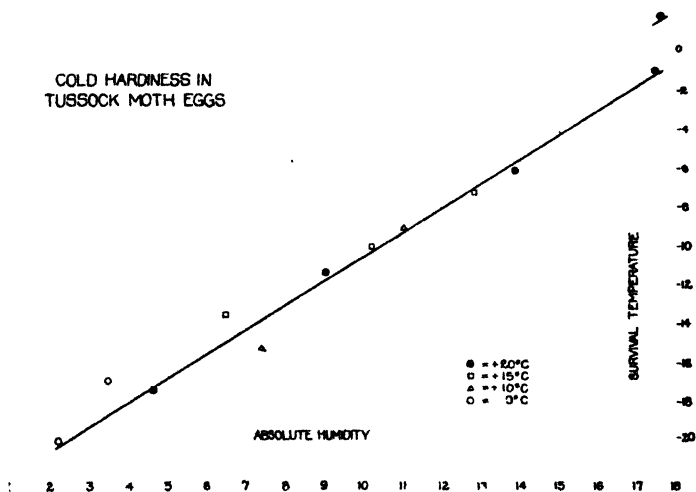


Fig. 2. Cold hardiness in tussock moth eggs as measured by survival temperature. Each reading represents an environmental temperature at which eggs were kept, at a given absolute humidity. With each environmental temperature, three different humidities were used.

of the 1500 tested in 1927-1928 is shown in Fig. 2 and Table III. Cold hardiness bears an inverse relationship to absolute humidity, the greater cold hardiness being associated with the lowest absolute humidity, regardless of temperature. The most cold-hardy egg thus far tested survived -28°C . Before using this figure as a cold hardiness limit for the species it must be remembered that this figure would hold only for eggs taken from the Philadelphia region or from similar climatic conditions. It was found in the case of the oak-borers, *Synchroa punctata*, and *Dendroides canadensis*, that specimens from Minnesota were more cold hardy than those from Pennsylvania. In Minnesota the most cold hardy oak borer survived -50°C ., in Pennsylvania -28°C .

COLD HARDINESS IN TUSSOCK MOTH LARVÆ.

Tussock moth larvæ of the 1st, 2nd, and 3rd instars of the over-wintering generation have also been studied. The larvæ can easily be reared on lettuce. Since these larvæ can be somewhat poisonous, especially to one handling them over long periods of time, they were transferred with brushes, and precautions taken to avoid touching either the larvæ or the hairs which they shed.

TABLE III.
COLD HARDINESS IN TUSSOCK MOTH EGGS.

Environmental Temperature	Survival Temperature	Relative Humidity in %	Absolute Humidity
20°C.	15 ± .5	100	17.5
	61 ± 1.3	80	13.9
	115 ± 2.4	50	9
15°C.	7. ± 1.7	100	12.8
	10. ± 2.25	80	10.2
	13.5 ± 3.1	50	6.5
10°C.	11. ± 2.3	100	9.2
	13.3 ± 3.2	80	7.4
	16.5 ± 5.6	50	4.6
0°C.	16.5 ± 4.1	100	4.6
	17. ± 3	80	3.5
	20 ± 5.3	50	2.2

Larvæ of the 1st instar of the over-wintering generation exhibited no marked periodicity in cold hardiness. The conditions under which they were reared in this experiment are admittedly highly artificial, and may fail to reflect a periodicity which would appear in specimens living out of doors at a variable temperature.

Larvæ hatching from cold hardy eggs tended to be cold hardy, but less so than the eggs. Tussock moth larvæ from eggs kept at 0°C. were more cold hardy than those from eggs kept at 20°C. The most cold hardy 1st instar larvæ thus far discovered survived -25°C.; the most cold hardy egg -27.5°C. Cold hardiness of the 1st instar larvæ kept at different environmental temperatures is shown in Table IV. As in the eggs, cold hardiness is a linear function of absolute humidity.

The ratio of cold hardiness in eggs to the cold hardiness of their larvæ could be tested for viable eggs only. There is no way to determine the possible cold hardiness of larvæ of non-cold hardy eggs which died during experimentation. This

TABLE IV.
COLD HARDINESS OF FIRST INSTAR TUSsock Moth Larvæ.

Environmental Temperature	Survival Temperature	Relative Humidity in %	Absolute Humidity
20°C.	14 ± 6	100	17.5
	4 ± 1.1	80	13.9
	9 ± 1.7	50	9
10°C.	9.5 ± 1.8	100	9.2
	11 ± 3.0	80	7.4
	14 ± 4.5	50	4.6
0°C	15 ± 4.3	100	4.6
	16 ± 2.8	80	3.5
	17.5 ± 4.9	50	2.2

limitation of the material was in part compensated by obtaining the survival temperatures of larvæ of moderately cold hardy eggs and comparing it with the survival temperatures of larvæ from eggs of greater cold hardiness. The relationship of cold

TABLE V.
EFFECT OF COLD HARDINESS OF EGGS OF TUSsock Moth ON Larvæ SUBSEQUENTLY HATCHED FROM THEM.

Survival Temperature of Eggs		Survival Temperature of Larvæ	
Mean	Minimum	Mean	Minimum
-20 ± 4.5	-27.5	-19 ± 3.2	-25.0
-15.4 ± 4.3	-23.1	-14.5 ± 4.5	-21.3
-10 ± 2.25	-15.1	-8 ± 3.	-13.7
-5 ± 1.2	-8.4	-5 ± 1.3	-7.2

hardiness of eggs to cold hardiness of larvæ subsequently hatched from them is shown in Table V. Both maximum and average cold hardiness are greater in the eggs than in the 1st instar larvæ.

The 1st instar larvæ were fed on lettuce and kept at temperatures of 0°C., 10°C., 15°C., and 20°C. Zero temperatures were maintained by keeping the larvæ in individual vials in thermos bottles filled with water and ice mixtures. Survival temperatures of the 2nd instars of these larvæ, together with the absolute humidities are shown in Table VI. For the 2nd instar larvæ of the over-wintering generation, cold hardiness, both maximum and average, is slightly less than that of the 1st instar larvæ. Cold hardiness is again a linear function of absolute humidity.

TABLE VI.

COLD HARDINESS OF SECOND INSTAR LARVÆ OF THE TUSSOCK MOTH.

Environmental Temperature	Absolute Humidity	Survival Temperature	
		Mean	Minimum
20°C.	17.5	— 1. ± .7	— 5 6
	13 9	— 3 1 ± 1.7	— 7 5
	9	— 8. ± 2 5	— 11
15°C.	12.8	— 5. ± 1.5	— 10 3
	10.2	— 7.9 ± 2 1	— 11 8
	6.5	— 8 8 ± 3 4	— 12 4
10°C.	9.2	— 7 2 ± 2 3	— 10 5
	7 4	— 10.3 ± 3 7	— 12 7
	4.6	— 12.9 ± 4 1	— 14.
0°C.	4.6	— 14.1 ± 5.	— 19 4
	3.5	— 15.7 ± 4 6	— 21.
	2 2	— 17. ± 2 3	— 23.

Larvæ were reared to the 3rd instar and again tested as for the 2nd instar. These results are given in Table VII. The most cold hardy larvæ survived $-17.8^{\circ}\text{C}.$ and the least cold hardy $-1.2^{\circ}\text{C}.$ Thus the 3rd instar larvæ were less cold hardy than the 2nd.

Experiments on the 4th and 5th instars, while not so extensive as those made on the 1st, 2nd, and 3rd, indicate that the 4th instar is less cold hardy than the 3rd, and the 5th is less cold hardy than the 4th. Maximum and average values of survival temperatures for 4th instar larvæ kept at 0°C. were $-15^{\circ}\text{C}.$ maximum, and $-11.5^{\circ}\text{C}.$ mean; for the 5th instar, $-13^{\circ}\text{C}.$ maximum, and $-8.5^{\circ}\text{C}.$ mean. Each of these values is based on 100 larvæ. Cold hardiness also appears to be a linear function

of absolute humidity in these as in the previous stages. Cold hardiness has not been determined for the pupa and the adult.

In the tussock moth no one stage exhibited periodicity in cold hardiness. If both egg and larval stadia are taken as a whole the organism can be said to be periodic, since each succeeding stage in the life history is less cold hardy than the one it follows. Even at constant temperature the individual larva loses cold hardiness with each molt. When the life history of the insect is considered it will be seen that with an insect hatching in the spring, the later stages normally appear in warmer weather than the earlier. Thus the older tussock moth larvæ are really late spring or early summer forms.

TABLE VII.

COLD HARDINESS OF THIRD INSTAR LARVÆ OF THE TUSSOCK MOTH.

Survival Temperature		Environmental Temperature	Absolute Humidity
Mean	Minimum		
-15.5 ± 1.5	-17.8	0°C.	2.2
-12.3 ± 2.2	-15.2	0°C.	4.6
-4 ± 1.3	-6	15°C.	12.8
-2 ± .8	-5.4	20°C.	13.9

Cold hardiness when measured by maximum cold hardiness for a stage held at the temperatures and humidities used, decreased with each succeeding stage. Mean survival temperature of eggs kept under conditions of 20°C. and 100% relative humidity (17.5 mm. absolute humidity) was $-1.5 \pm .5^{\circ}\text{C}.$; mean survival temperature for 1st instar larvæ, was $-1.4 \pm .6^{\circ}\text{C}.$; for the 2nd instar $-.8 \pm .3^{\circ}\text{C}.$; for the 3rd $-.5 \pm .2^{\circ}\text{C}.$ For this high temperature and humidity (both relative and absolute) the difference between cold hardiness of eggs and 1st instar larvæ is not significant. For lower temperatures and lower humidities differences between successive stages are larger. It may be that at as high a temperature as 20°C. and humidity at saturation (100% relative humidity) whatever periodicity is inherent in the organism is concealed, or may actually be removed by the environment. At 20°C. and 80% relative humidity, significant differences in cold hardiness did appear between each stage in the life history of the tussock moth. Tussock moths can be reared from egg to pupa at $+10^{\circ}\text{C}.$,

+15°C., or +20°C. Eggs can be kept at 0°C. for 6 months and still retain their viability. First instar larvæ can survive at 0°C. for 4 months. These long exposures of tussock moth eggs and larvæ to 0°C. were carried out at approximately saturation (100% relative humidity or 4.6 mm. absolute humidity). At 10°C. and saturation, eggs could be kept for 9 months, and at 80% relative humidity for an equal period of time. In long time exposures relative humidity was hard to control accurately except at saturation. First instar larvæ can be kept at 10°C. at saturation for 3 months; 2nd instar larvæ for 2 months and 3rd instar larvæ for 3 weeks. At saturation humidities, larvæ succumb very easily to fungus infections. The larvæ were not reared under sterile conditions. It may be that they are more adapted to the quantity factor of low temperature than the experiment would indicate.

Larvæ do not resist drying over long periods of time. Eggs however may be kept over CaCl_2 for as long as 2 years, and after soaking they have the ability to hatch. With the eggs, not only cold hardiness to the intensity factor, but cold hardiness to the quantity factor also is associated with low humidity, (both relative and absolute).

Thus in the tussock moth we have an insect cold hardy to both the intensity factor and the quantity factor of low temperature. Cold hardiness to the intensity factor is periodic for the organism as a whole, but not for any one stage, and in each stage bears a close relationship to the absolute humidity and to the temperature of the environment.

Since cold hardiness in the tussock moth is correlated with three external environmental factors, all of which are mathematical functions of each other, it was thought that a nonogram would be the best means of showing the interrelation of these three factors (environmental temperature, relative humidity and absolute humidity) to cold hardiness. This method of graphical representation has been used by Henderson (1921) in his studies on the respiratory function of the blood. It is fully explained in Pearl's *Medical Biometry* (1923).

Cold hardiness at a given temperature, relative humidity, or absolute humidity can be read off the nonogram. From experimental data at hand it would seem possible to interpolate cold hardy values, at least between -4.0°C. and -20°C. for tussock moth eggs and 1st instar larvæ, and between -1.5°C.

and $-20^{\circ}\text{C}.$ for the 2nd instar larvæ where temperatures given represent the survival temperature. Extra-polation would not seem justified, since at the extremes of cold hardiness there is more variability than at intermediate temperatures. For example with the present state of knowledge it would be possible to predict the survival temperature of an egg or larva kept at $+15^{\circ}\text{C}.$ or conversely it would be possible to determine at what temperature and humidity an egg or larva would need to be kept in order to survive $-12^{\circ}\text{C}.$, but it would not be possible to predict the temperature and humidity combination necessary to produce an egg or larva capable of withstanding $-30^{\circ}\text{C}.$

Nonograms have been constructed which show the relationship of environmental temperature, relative humidity, absolute humidity and survival temperature of the egg, 1st instar, and 2nd instar of the tussock moth, (Fig. 3).

COLD HARDINESS IN THE JAPANESE BEETLE.

Japanese beetle larvæ (*Popillia japonica* Newman) are remarkably cold hardy to the quantity factor of low temperature, but only moderately so to the intensity factor. They are, however, able to withstand intense dehydration, but not dehydration over long periods of time. They can survive dessication with a water loss of one-third their body weight, but cannot survive long periods of exposure to drying.

With regard to the intensity factor of low temperature, the three instars behave almost alike, except that the 1st instar is slightly less cold hardy than the 2nd and 3rd. A scale of cold resistance of -7° to $-15^{\circ}\text{C}.$ covers the range of temperature below zero usually survived by the 2nd and 3rd instars, and -7 to $-12^{\circ}\text{C}.$ covers the survival range of the 1st instar larvæ.

A nonogram of the temperature-humidity relationships of the larval instars, and of the adult is shown in Fig. 4. The adult behaves differently with regard to cold hardiness than does the larvæ. It is cold hardy to the intensity factor of low temperature, can survive extreme dehydration, but is not so well adapted to the quantity factor of low temperature as is the larvæ. Although the adult is a summer stage in the life history of *P. japonica* it is as cold hardy as larvæ of oak borers found in Minnesota during the winter. The cold hardy range of the

Japanese beetle adults found in and near Philadelphia is from $-20^{\circ}\text{C}.$ to $-40^{\circ}\text{C}.$ No studies of blood conductivity or freezing point could be made on them because enough blood or

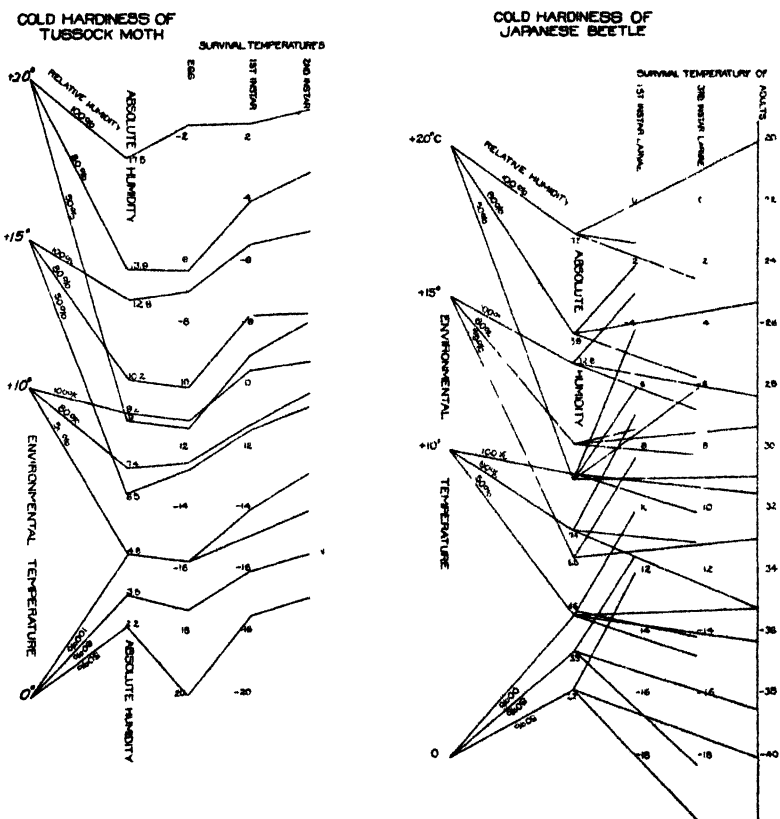


Fig. 3. Cold hardness in tussock moth eggs and larvæ. The first ordinate from the left records environmental temperature, the second ordinate absolute humidity, the third, fourth, and fifth ordinates represent survival temperatures of egg, first instar and second instar larvæ respectively. The sloping line connecting environmental temperature to absolute humidity is relative humidity. In reading chart, trace the survival temperature of any given stage, back to its corresponding humidity and environmental temperature.

Fig. 4. Cold hardness of Japanese beetle. Environmental temperature is the first ordinate, absolute humidity the second, and the third, fourth, and fifth, ordinates are survival temperatures of the first instar larvæ, third instar larvæ, and adults, respectively. The sloping line connecting environmental temperature and absolute humidity is relative humidity. In reading chart, trace back the survival temperature of any stage to its corresponding humidity and environmental temperature.

body fluid for a test could not be obtained, even upon extensive dissection. Since previous studies have shown that low moisture content is in general associated with cold hardiness to the intensity factor of low temperature, it may be that the beetle is so constituted that it must be cold hardy. However the cold hardiness of this beetle can be increased still further by exposure to lower temperatures and low humidities, (both relative and absolute). In the nonogram, Fig. 4, cold hardiness is shown for environmental temperatures of 0°C., 10°C., 15°C., and 20°C., and for relative humidities of 50% to 100%, with their corresponding absolute humidities. Exposure to a given temperature was for 5 days in all of the experiments charted on the

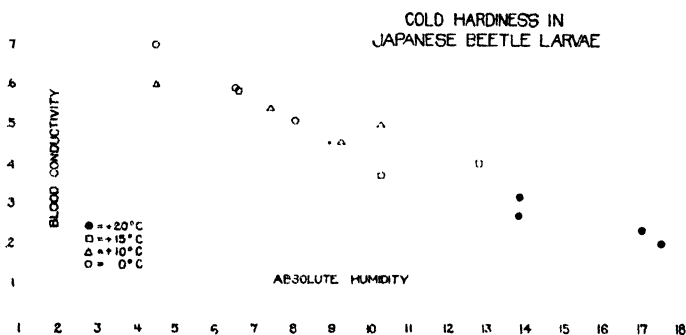


Fig. 5. Cold hardiness in Japanese beetle larvæ as measured by blood conductivity. Blood conductivity is plotted against absolute humidity. Each reading represents a given environmental temperature. Each temperature was used with several humidities.

nonogram, Fig. 4. There appears thus far to be no periodicity in cold hardiness in the adult of the Japanese beetle.

From the larvæ enough body fluid could easily be obtained to make readings of conductivity, pH, or freezing point. In a previous paper, Payne (1927), blood conductivity was used as a measure of cold hardiness in the Japanese beetle 3rd instar larvæ. The figures obtained, plotted against the absolute humidity of the environment in which the larvæ were kept is shown in Fig. 5. There is a tendency for the conductivity to be correlated with absolute humidity, but the correlation is not a linear one as was found for tussock moth eggs and larvæ. Conductivity is not a perfect measure of cold hardiness, and therefore it might be expected that even if the survival tem-

perature and absolute humidity were correlated, the blood conductivity and absolute humidity would show a lower coefficient of correlation than a more direct measure of cold hardiness.

The nonogram of cold hardiness relationships of the Japanese beetle, (Fig. 4), show that environmental temperature is more

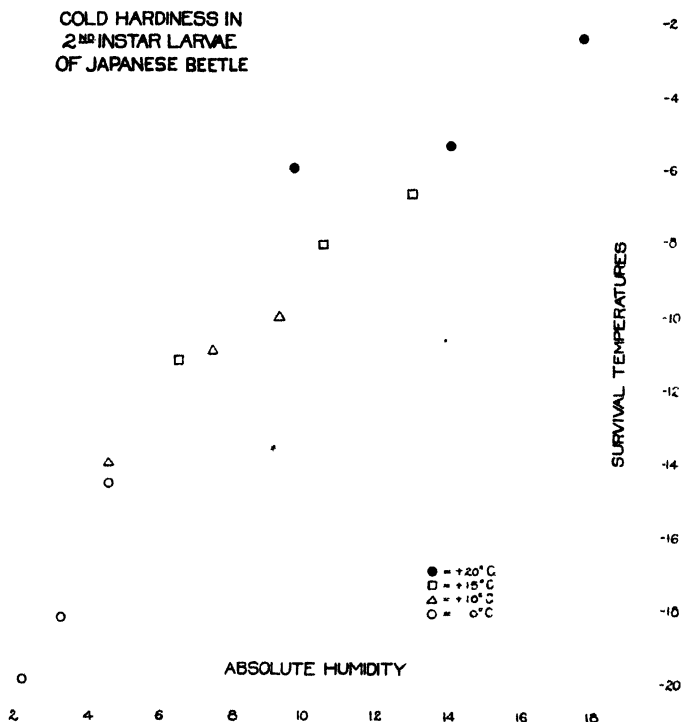


Fig. 6. Cold hardiness in the second instar larvæ of the Japanese beetle. Absolute humidity is plotted against survival temperature. Each reading represents an environmental temperature at which larvæ were kept, at a given absolute humidity. With each environmental temperature several humidities were used.

closely related to cold hardiness than is absolute humidity. For example, at an absolute humidity of 4.6 mm. water vapor, the survival temperature of the 3rd instar at 0°C. was $-14.6^{\circ}\text{C}.$, at $10^{\circ}\text{C}.$ was $-1.4^{\circ}\text{C}.$; at absolute humidity of approximately 9 mm., for 3rd instar larvæ kept at $+10^{\circ}\text{C}.$ the survival temperature was $-10^{\circ}\text{C}.$, for those kept at $+20^{\circ}\text{C}.$ the survival temperature was $-6^{\circ}\text{C}.$ The 1st difference cited is not signi-

ficant, as it is less than the standard deviation for the mean; the second is probably significant. The 2nd instar larvæ behaved like the 3rd, (Fig. 6). Neither in mean or minimum survival temperatures was there a significant difference between them. In Fig. 7 survival temperatures of 1st instar larvæ are plotted against absolute humidity. There is a correlation of survival temperature and absolute humidity in both larval instars of the Japanese beetle, but in neither is survival temperature a linear function as in all stages of the tussock moth.

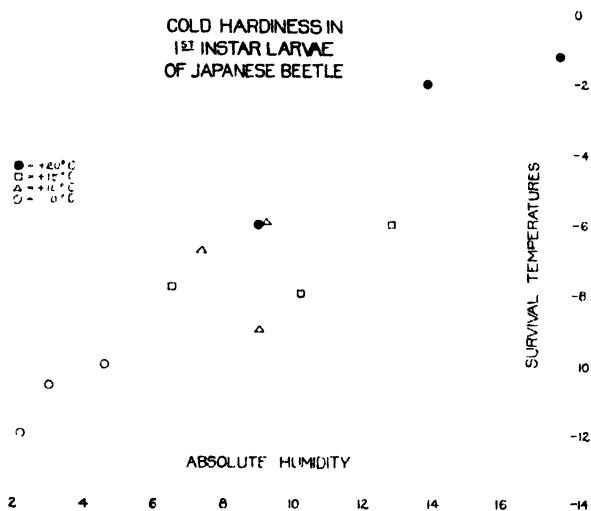


Fig. 7. Cold hardiness in the first instar larvæ of the Japanese beetle. Each reading represents an environmental temperature at which larvæ were kept at a given absolute humidity. With each environmental temperature several humidities were used.

ABSOLUTE HUMIDITY AS A FACTOR IN COLD HARDINESS IN THE OAK BORER.

Data comparable to that obtained for the Japanese beetle and the tussock moth was not determined for the oak borers, neither in Minnesota nor in Pennsylvania. However the concept of absolute humidity as a factor in cold hardiness clears up certain discrepancies between experimental results and out-of-door observations made in that ecological group. It was shown experimentally that exposure to low temperature increased cold hardiness. Dehydration or exposure to low

relative humidities at room temperature (20°C. - 22°C.) also increased cold hardiness. In making climographs of the Minnesota climate near St. Paul, it was found that the highest relative humidity occurred in winter. Larvæ kept out of doors in winter, or collected from moist (at times saturated) environments were still cold hardy, although it was found in general that high humidity was associated with loss of cold hardiness. With the concept of absolute humidity this apparent conflict of experimental results with observations is at once eliminated, for in winter in Minnesota the absolute humidity of the environment of the oak borers *Dendroides canadensis* and *Synchroa*

TABLE VIII.
METEOROLOGICAL DATA, 1927, PHILADELPHIA.

Month	Temperature	Precipitation	Relative Humidity
January.....	33	1.88	74
February.....	41	3.66	78
March.....	54	1.11	79
April.....	60	3.66	74
May.....	70	1.75	82
June.....	78	3.48	73
July.....	84	4.50	74
August.....	78	7.27	81
September.....	78	2.59	73
October.....	68	5.71	73
November.....	58	3.59	77
December.....	46	3.99	70

punctata was low. In experimental hardening likewise the absolute humidity was low. Thus in the oak borer group as well as in the Japanese beetle, *Popillia japonica*, and the tussock moth, *Hemerocampa leucostigma*, low absolute humidity is associated with cold hardiness.

GENERAL DISCUSSION.

In this paper emphasis is laid on one factor in cold hardiness, namely absolute humidity, the relationships and ramifications of which were determined in some detail in two organisms, *Popillia japonica*, Newman, and *Hemerocampa leucostigma* Smith and Abbott. The writer hopes that in bringing this one environmental condition to the front its limitations will not be lost sight of by the reader. Absolute humidity, which is

essentially but one factor in measuring moisture, does not determine the total amount of intensity of low temperature that an animal will survive. Various internal factors such as nutrition, water binding ability (Robinson 1927), health, and above all previous history of the animal upon which experiments performed or determinations are made play important roles in the ability to withstand low temperatures. For example, in the Japanese beetle larvæ a freshly molted larvæ of any of the three instars is not cold hardy. Japanese beetle larvæ with clear digestive tracts are not cold hardy regardless of environment.

TABLE IX
METEOROLOGICAL DATA, 1928, PHILADELPHIA.

Month	Temperature	Precipitation	Relative Humidity
January	35 6	1 91	70%
February	35 1	4	73%
March	42	2 10	72%
April	50 6	5 55	70%
May	62.4	2 19	72%
June	69 8	6 77	80%
July	77 4	3 60	77%
August	77 2	5 47	82%
September	65 4	3 61	77%
October	59 9	.73	80%
November	49.	1.94	78%
December	40 8	1 5	70%

Cold hardiness as determined for the species studied at Philadelphia, *Popillia japonica* and *Heemerocampa leucostigma*, will very probably not hold for these same species collected in different climates, or reared at different temperatures. In order that the results found in this paper may be compared with those found in other regions, a climograph for the Philadelphia region, showing relative humidity plotted against temperature, (Fig. 8), and one showing precipitation plotted against temperature, (Fig. 9, Tables VIII and IX), are shown. The tussock moth eggs are exposed to the extremes of low temperature occurring in this region. The Japanese beetle larvæ live in the earth, generally in moist, rarely in sandy soil, and are thus exposed to neither the extremes of humidity or temperature to which tussock moths are exposed.

SUMMARY.

1. Cold hardiness in the eggs and larvæ of the white marked tussock moth, *Hemerocampa leucostigma* Smith and Abbott, bears a linear relationship to absolute humidity.

2. Eggs are slightly more cold hardy than the 1st instar larvæ; the 1st instar larvæ more cold hardy than the 2nd, and the 2nd more than the 3rd.

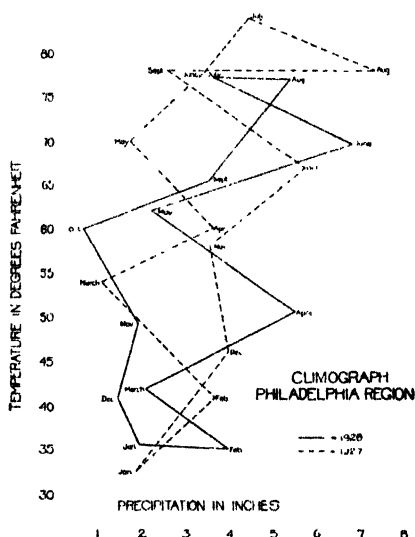
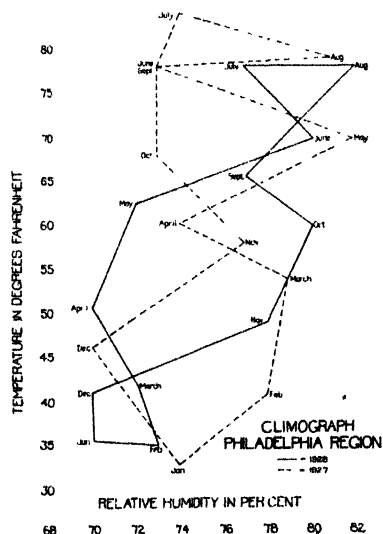


Fig. 8. Climograph of the Philadelphia region. Average monthly temperature in degrees Fahrenheit is plotted against relative humidity as expressed in per cent.

Fig. 9. Climograph (hythergraph) of the Philadelphia region. Average monthly temperature in degrees Fahrenheit is plotted against precipitation expressed in inches.

3. Cold hardy eggs tend to produce cold hardy larvæ.

4. Cold hardiness of the Japanese beetle in relation to absolute humidity, relative humidity and environmental temperature has been determined for all three instars of the Japanese beetle larvæ, *Popillia japonica* Newmann, and for the adults.

NUTRITION AS A FACTOR IN INSECT COLD HARDINESS.

Nutrition influenced the cold hardiness of Japanese beetles kept at the same temperature and relative humidity. Diets used for Japanese beetles consisted of vegetable mold from grasslands (not leaf mold), and of vegetable mold plus wheat. The addition of wheat to the leaf mold increased cold hardiness as shown in Tables X and XI.

TABLE X.

EFFECT OF NUTRITION ON COLD HARDINESS OF JAPANESE BEETLE LARVÆ OF THIRD INSTAR. (MEASURED AS SURVIVAL TEMPERATURE). SATURATION OR 100% RELATIVE HUMIDITY.

	Vegetable Mold	Starved Two Weeks	Starved Four Weeks
Kept at 20°C	-2.5 ± .9	-5.3 ± 1.4	-1.2 ± .3
Kept at 15°C	-6.5 ± 1.4	-8.9 ± 2.0	-4.1 ± 1.6

Starvation of 3rd instar larvæ for two weeks increased their cold hardiness. Starvation for one month decreased it. During starvation larvæ were kept in separate vials in sterile white sand moistened with distilled water.

TABLE XI.

EFFECT OF DIET ON COLD HARDINESS OF JAPANESE BEETLE LARVÆ OF THIRD INSTAR. (MEASURED AS SURVIVAL TEMPERATURE). 80% RELATIVE HUMIDITY.

	Vegetable Mold	Vegetable Mold Plus Wheat	Starved Two Weeks
Kept at 20°C	-3.5 ± .7	-6.0 ± 1.5	-7.5 ± 1.9
Kept at 15°C	-6.8 ± 1.3	-7.2 ± 2.15	-10.4 ± 2.7

ACKNOWLEDGMENTS.

This work was done at the University of Pennsylvania, Department of Zoology, at which place apparatus and facilities for study were made available. To Dr. J. H. Bodine, of the Dept. of Zoology, I owe thanks for helpful suggestions during the course of the work. Dr. Henry Fox, of the Japanese Beetle Laboratory, aided greatly by furnishing the large quantities of

Japanese beetle larvæ used in these experiments. To him I owe thanks for helpful counsel. Finally Dr. H. B. Baker, of the Dept. of Zoology, proposed the concept of absolute humidity as a key to the anomalous behavior of certain organisms with respect to cold hardiness.

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BOOK NOTICE.

REVISION DER PHORIDEN NACH FORSCHUNGSGESCHICHTLICHEN UND NOMENKLATORISCHEN, SYSTEMATISCHEN UND ANATOMISCHEN BIOLOGISCHEN UND FAUNISTISCHEN GESICHTSPUNKTEN, von Dr. Phil. Nat. Hermann Schmitz S. J. of Ignatius-Kolleg, Valkenburg. Published by Ferd. Dummlers Verlag, Berlin SW 68. Quarto, 212 pages, 48 text figs., 2 pls.

This is a beautifully arranged monograph and review of the biological facts known about this family of parasitic flies with keys to genera and a list of the European species with notes on their distribution. It contains considerable original material on the anatomy particularly of the curious glands found in such parasitic insects. The excellence of the volume lies in the painstaking analysis of the material and arrangement of the contents. Any systematist planning a monograph would find this volume full of suggestions as to the arrangement. Some of the twelve parts are: History of the literature and research; Research on types; Natural boundaries of the family; Origin and relationships of the Phoridae; Anatomy; Classification and keys to genera; Revision of genera; Distribution of European species; Bibliography; Index. The chapter, "Research on types," gives the location and present standing of each author's types and must represent a great amount of labor. It is the type of research that too many systematists avoid. The press work is of the highest standard.

C. H. K.

NATURAL ENEMIES OF THE SUGAR CANE MOTH STALKBORER IN CUBA.¹

H. K. PLANK,
Central Baraguá, Prov. Camagüey, Cuba.

INTRODUCTION.

The habit which the sugar cane moth stalkborer (*Diatraea saccharalis* Fabricius) has of spending the greater part of its life in tunnels in the stalks of sugar cane, corn, and certain grasses serves as an admirable protection against direct, or artificial, measures of control (9),² but does not seem to afford any great amount of protection against the attack of a rather formidable array of natural enemies. Such a condition is indicated in the comprehensive list of sugar cane moth borer parasites recently published by Van Dine (13). In this list, which includes the parasites reported from different parts of the world, there are ten species credited to Cuba. Among these is *Bassus (Microdus) stigmaterus*, described by Cresson from Cuba in 1865 (2), and reported by Holloway and others (3, 5) as being a parasite of *Diatraea saccharalis*, as well as four other species reported by Cardin in 1915 (1). Since 1915 the remaining five species have been reported by various authors.

In the investigations conducted by the Cuba Sugar Club Experiment Station since 1925, all but two of the ten parasites listed have been encountered. Observations and records on these and a number of other parasites, as well as predators, have been made under various conditions. It is the purpose of this paper to present these observations, together with a summary of all the information available up to the present time, to serve as a guide should efforts be made to introduce and colonize new species. The species are treated in the order of their abundance and placed in groups according to their major or minor importance.

¹Scientific Contributions No. 15, Tropical Plant Research Foundation. From the Cuba Sugar Club Experiment Station, Baraguá, Province of Camagüey, Cuba.

²Figures in parentheses refer to the "List of References" at the end of this report.

MAJOR PARASITES.

The species considered under this heading have been encountered most frequently in Cuba. Collectively they have been observed to parasitize about half of the borers in some localities during certain seasons of the year.

Lixophaga diatraeae Townsend.³

Lixophaga diatraeae Tns. (Figs. 1 and 2)⁴, commonly referred to as "The Tachinid," or "Cuban Fly," has been found in more localities in the Island of Cuba than any other parasite.

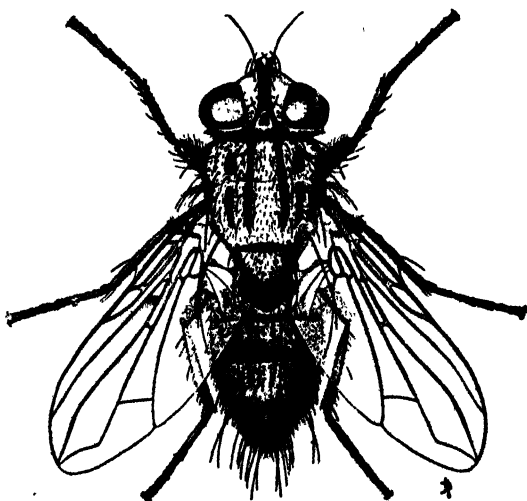


FIG. 1. *Lixophaga diatraeae* Townsend, "Tachinid," or "Cuban fly," parasite of the sugar cane moth stalkborer, greatly enlarged. (Holloway, Haley, and Loftin).

Wolcott (16) found it in various places in the provinces of Habana, Santa Clara, Matanzas, and Oriente in 1914, and estimated that "25 per cent of the borer larvae in Cuba that are half grown or larger will be found to be parasitized by the Tachinid fly maggot." Holloway and Loftin (3, 4), who collected and sent more than 650 of the puparia of this fly to Louisiana, estimated that "from 20 to 50 per cent of the moth

³Order Diptera, family Tachinidæ.

⁴The photographs for all except Figures 1 and 6 were made by Mr. L. C. Scaramuzza.

borer larvæ were parasitized" at Central Mercedes, Matanzas Province, in the summer of 1918. Van-Zwaluwenburg (14, 15) collected puparia of this parasite for shipment to Mexico during the summer of 1922 and found it very abundant in the provinces of Habana and Matanzas. Salt (10) found *Lixophaga* present in about 3.5% of the infested canes at Central Soledad, Santa Clara Province, in 1926. In the field survey made by this Station during the crop of 1927-28, in which were included

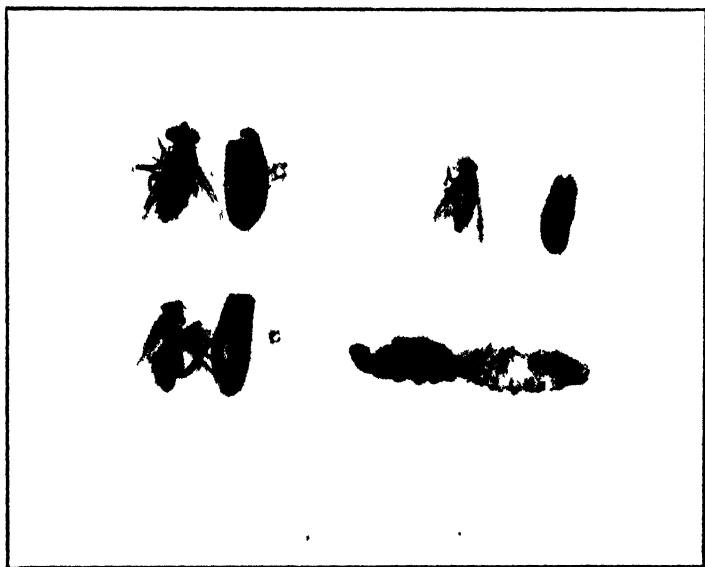


FIG. 2. *Lixophaga diatraeae* Townsend, "Tachinid," or "Cuban fly," parasite of the sugar cane moth stalkborer, mounted to show various views of the adult and range in size of the adults and of the puparia (shown at right of each). Remains of a borer killed by the maggot shown at lower right. Enlarged twice.

eight centrals in the provinces of Matanzas, Camaguey, and Oriente, puparia of this fly were found at all but one central. The average percentage of parasitized borers at the time the collections were made at these seven mills was 9.7%, of which 8.8% were *Lixophaga*. A survey of 32 centrals, including the above, in six provinces, made from December, 1928, to May, 1929, showed that this parasite was present at all but two centrals. (See Table I). It is very probable that if more extended observations could be made at these two centrals,

Lixophaga would be found there also. It is thus seen that this species has been found in all of the provinces and that it is well distributed over the entire Island.

TABLE I.

DISTRIBUTION OF THE MAJOR PARASITES OF THE SUGAR CANE MOTHS
STALKBORER, CUBA, 1926-1929, INCLUSIVE.

PROVINCES AND CENTRALS VISITED	SPECIES FOUND, OR REARED			
	<i>Lixophaga</i>	<i>Apanteles</i>	<i>Bassus</i>	<i>Trichogramma</i>
Pinar del Rio				
San Cristobal	X	X	X	
Orozco	X			
Marcedita	X			
Total, 3	3	1	1	
Habana				
Hershey	X			
Gomez Mena	X			
Total, 2	2			
Matanzas				
Conchita	X	X		
Cuba	X	X	X	X
Mercedes	X			
Total, 3	3	2	1	1
Santa Clara				
Soledad (Cienfuegos)	X			
Trinidad	X			
Adela	X			
Total, 3	3			
Camaguey				
Jathibonico	X			
Punta Alegre	X			
Moron	X			
Jagueyal	X			X
Baragua	X	X		
Jaronu	X	X	X	X
Florida	X			
Agramonte	X			
Vertientes	X			
Santa Marta	X		X	
Total, 10	10	2	2	2
Oriente				
Jobabo	X		X	
Rio Cauto	X		X	X
Cupey	X			
Maceo				
Baguanos				
Tacajo	X			
Preston	X			X
Miranda	X			
Ermita	X		X	
Cape Cruz	X			X
Isabel (Media Luna)	X			
Total, 11	9		3	3
Grand Total, 32	30	5	7	6

Table II shows the results of the examinations made on the seasonal occurrence of the natural enemies of the borer at Central Jaronù during the three years 1926 to 1928. This

TABLE II.

OCCURRENCE OF THE NATURAL ENEMIES OF THE SUGAR CANE MOTH STALKBORER, CENTRAL JARONÙ, CAMAGÜEY PROVINCE, CUBA, 1926-1928, INCLUSIVE.

SPECIES	Living parasites found, or reared, from borer eggs ("e"), larvæ ("l"), and pupæ ("p").											
	Jan	Feb.	Mar.	Apr.	May	June	July	Aug	Sept	Oct.	Nov.	Dec.
Parasites:												
<i>Lixophaga diatraea</i> Tns	1 p	1	1	1, p	1	1, p	1, p	1	1	1	1	1, and on wing
<i>Apanteles diatraea</i> Mues	1	1				1	1	1	1	1	1	1
<i>Basius stigmatorius</i> (Cress.)	1		1		1	1	1, p				1	
<i>Trichogramma minutum</i> R			e									
<i>Sarcophaga sternodontis</i> Tns	p	p			p	1, p	p	p	p	p		
<i>Sarcophaga helictis</i> Tns							1		1			
<i>Sarcophaga surrubea</i> VDW						1 p				1		
<i>Sarcophaga pedata</i> Al ¹							p					
<i>Chactopsis flavifrons</i> Mace.,					p							
Predators:												
<i>Prolabis unidentata</i> Pabis		1					p	1		1	1	
<i>Doru lineare</i> Es. h	p											
<i>Anisobius</i> sp	p											
<i>Anisobius annulipes</i> Luc								p	p			
<i>Periphorus</i> spp							p				p	
<i>Leion</i> , sp					1							
<i>Monomorium flavicola</i> Jerd					1							
<i>Solenopsis corticalis</i> var.								1				
<i>Prenolepis</i> sp									1			
Undetermined ants						p	1		p			

central is located on the north coast of the province of Camagüey. It will be noted that living specimens of *Lixophaga* have been seen, or have been reared from borer larvæ, in every month of the year. In addition, from collections of borers made in January, April, June, and July *Lixophaga* was reared from the borer pupa, and in December specimens of the adult, or fly, were seen flying about in the cane fields.

Observations made at frequent intervals, in certain fixed areas, and extending over long periods have shown that the

percentage of parasitism by *Lixophaga* is quite variable throughout the year and from year to year. In one locality in 1926 it varied from 10% in July to about 40% in September (8). In another similar locality during 1927 an average of 7.6% was noted for the period from April to the following February. In this case the maximum efficiency of the parasite was exhibited during April and the minimum during July.

The method by which this parasite deposits its eggs has not been discovered. Numerous attempts have been made to induce oviposition in various types of laboratory cages, but all have been unsuccessful. No observations have been made in the field which would give an indication of the egg-laying habits.

Lixophaga diatraea is a parasite of the larva of *Diatraea* that occasionally delays its emergence until after the borer has pupated. Holloway (3) and the writer have reared it a number of times from borer pupæ, but these instances were rare when compared with the frequency with which it was recovered from the larva. Rarely has it been reared from borer larvæ less than one-third to one-half grown when collected, and the borers were nearly always full grown by the time the parasite larvæ, or maggots, emerged from them. Usually only one parasite maggot has issued from a borer larva or pupa, but occasionally two and less frequently three have been seen to emerge.

When full-grown the larva of *Lixophaga* occupies nearly all of the interior of the host and its movements therein make the latter appear to be alive up to the time when emergence takes place. After emergence the maggot seeks a dry place in which to change to the pupal stage. (See Fig. 3). This change usually takes place within a few hours, but has been observed to require a much longer time. Wolcott (16) found 2 days the maximum time required during the winter of 1914.

When the puparium, or transition stage from larva to fly, is first formed it is light yellow in color, but changes within a few hours to amber color and finally to black by the time the fly is ready to emerge. It is always slightly curved with the ends well rounded as shown in Figs. 2 and 3. In the young cane shoots it is usually formed at or near the opening of the borer tunnel, often some distance above the remains of the borer larva, which thus insures its exit from the cane stalks.

Sometimes it will be found between the loose dry outer leaves, especially if the shoot be large and almost dry. In stalks that have developed joints, the puparium will be found in or near the mouth of the larger borer tunnels and within about two inches from the outside (Fig. 3, "P"). Nearly always this part of the exit tunnel has been found open and free from the usual silk and other material which the borer places there before it pupates. The fly is thus able to find its way to the outside when it emerges from its puparium.

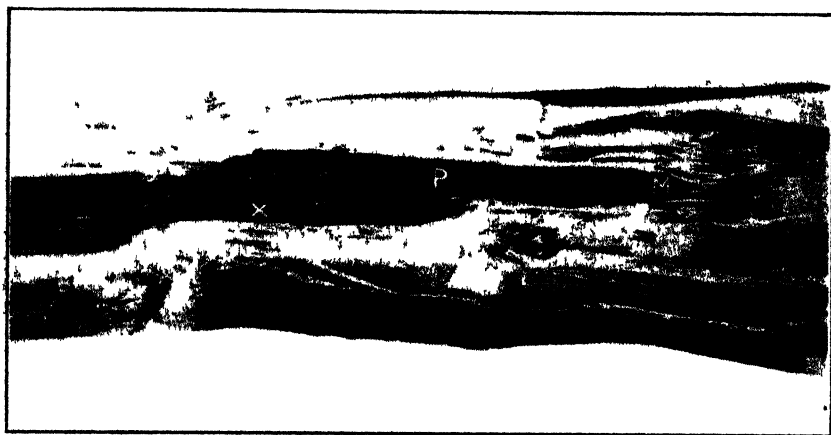


FIG. 3. Piece of cane stalk opened to show relative position of puparium, "P," of *Lixophaga diatraea* Tns. near mouth, "M," of tunnel made by the sugar cane moth stalkborer. Remains of borer larva shown at left of "X." Enlarged twice.

Inasmuch as it is not known when egg-laying takes place, the length of time required for the larval stage cannot be given. Sometimes as many as 25 days elapse after the borer larva has been collected in the field before the parasite larva emerges. The average time noted between collection and emergence of the parasite was about 8 days.

The length of time in the pupal stage has been observed to vary from 7 to 11 days, about 10 days being the average under conditions normally found in Cuba during May, June, and July. In cool weather, or in artificially cooled containers, this period may be prolonged to double the time without apparent injury to the emerging fly. This is of great importance in considering the shipment of the fly from one country to another.

After normal emergence, the adults may live as long as three days without food. With sugar syrup, or other suitable material, their life may be prolonged, but, even when thus fed in a protected screen cage in an outdoor rearing shelter, all were dead within a period of 10 days. No observations have been made on the mating habits.

Very few natural enemies of *Lixophaga* have been found in Cuba. While making some examinations in young cane at Central Jaronù, W. E. Haley of the U. S. Bureau of Entomology found four *Lixophaga* puparia that had been eaten into presumably by a species of earwig. The writer found some small maggots feeding on a *Lixophaga* larva that had just issued from a borer in its tunnel. The flies reared from these maggots were subsequently determined as *Aphiochaeta* sp. by C. T. Greene of the U. S. National Museum. In 1919 Holloway (3) wrote that *Lixophaga* has to contend with a secondary parasite in Cuba, but did not state what it was. No secondary parasites have been encountered in the present work.

From the data gathered thus far in districts which are located on the north coast of the province of Camaguey, it appears that rainfall and the predominance and availability of certain stages of the larvæ of *Diatraea* are the most important limiting factors in the efficiency and development of *Lixophaga*.

The highest percentage of parasitized borers was generally found to coincide with or follow periods of rainfall. In 1926, a year of excessive rainfall, except in March and May, there was an increase in the percentage of parasitized borers found, from 10% in July to 40% in September. During 1927, a year of light rainfall, except in March, August, and September, the percentage of parasitized borers showed a decided decrease as the season advanced and during June, July, and August practically none could be found. After August 15 the borer population gradually increased with the age of the cane, and parasitism then seemed to follow more closely the periods of greatest abundance of the one-third- to one-half-grown borers, but never became greater than 17.5%.

That the majority of flies are on the wing and that parasitism takes place generally during these periods is clearly indicated by the fact that the largest numbers of empty *Lixophaga* puparia are found during or just before these periods. Since at almost any time of the year more puparia are found in the

dead hearts than in the stalks, it appears that the size of the infested stalk, and hence the availability of the borer for parasitism, also has some influence on the seasonal abundance of *Lixophaga*.

The most important artificial condition that limits the abundance and effectiveness of *Lixophaga* is the burning of the cane trash, either before or after harvest. This conclusion is based on observations made in 1926 (8) and 1927 of both burned and unburned fields. The two fields under observation in 1926 were again examined on April 12, 1927, 11 weeks after the previous crop had been harvested and about 10 weeks after the trash in the burned field had been burned off. The examination in the burned field yielded no parasites, while 19.2% of the borers collected in the adjacent unburned field harvested at the same time were found to be parasitized by *Lixophaga*. Unfortunately an accidental fire swept over the unburned field and made further examinations along this line impossible. Observations made in burned-over fields elsewhere, however, showed that parasitism was not effective until late in the season, at which time the borer infestation was much greater and the parasitism much less than in the nearby unburned fields of the same age.

Another artificial condition that limits the abundance of this Tachinid parasite is the removal of dead hearts as a plantation measure in borer control. This was indicated in the dead heart cutting experiment conducted in 1926 (7). In the examinations made in January, about 6 months after the latter of the two cuttings was completed, it was discovered that there were approximately one-half as many borers parasitized by *Lixophaga* as in the adjacent check fields. In this case the dead hearts were removed and destroyed without any effort being made to allow the parasites to emerge and return to the fields.

Mention should be made here that, through cooperative arrangements between the U. S. Bureau of Entomology and the Florida Agricultural Experiment Stations, 1760 larvæ and puparia of *Lixophaga* were sent to the United States for colonization at Bradenton and Lake Alfred, Florida, during 1926 and 1927.

***Apanteles diatraeæ* Muesebeck.⁴**

This parasite was first reported in Cuba by Cardin in 1915 (1) as *Microgaster* sp., and during the early part of the present investigation Van Dine (12) and the writer (8) used the name *Microgaster* sp. to designate this parasite. Recently, however, Cardin's material was made available by Mr. S. C. Bruner of the Estacion Experimental Agronomica at Santiago de las Vegas. This material and specimens reared by the writer were



FIG. 4. *Apanteles diatraeæ* Muesebeck, parasite of the sugar cane moth stalk-borer, enlarged twice. Remains of a borer killed by the grubs at left, groups of cocoons taken from borer tunnels in center, and adult parasites at right.

referred to A. B. Gahan of the U. S. National Museum for determination. Mr. Gahan identified all specimens as *Apanteles diatraeæ* Mues. As a result of this determination, the mention of *Microgaster* sp. in Van Dine's list (13), on the authority of Cardin, refers to the species under discussion.

Apanteles diatraeæ (Fig. 4, right), is a small parasite of the borer larva and has ranked next to *Lixophaga diatraeæ* Tns. both in abundance and importance. Holloway (3) states that U. C. Loftin he and found what was subsequently determined as *Apanteles* sp. "comparatively rare" at Mercedes, Matanzas

⁴Order Hymenoptera, family Braconidæ.

Province, during 1915 and 1918. The specimens collected by Mr. Holloway at this place in September, 1918, were described by Muesebeck in 1920 (6) as *Apanteles diatraeæ* n. sp. Van Zwaluwenburg (15) reared the same species from material collected in *Diatraea* tunnels in sugar cane in the province of Matanzas, Cuba, where he said it appeared to be uncommon. The writer has found this parasite at five other centrals in the provinces of Pinar del Rio, Matanzas, and Camaguey. (See Table I). While this parasite is now known to occur in Cuba in only these three provinces, it is probably present in other parts of the Island as well.

In the northern part of Camaguey Province where the following observations were made, living specimens of this parasite were found in all months of the year except March, April, and May. (See Table II). The period of greatest activity was confined to the late summer, fall, and winter months. During these periods as high as 4% of the borers collected were parasitized by this species but the average is much less.

All attempts to induce egg-laying in cages were unsuccessful. Several types of cages were used and borers varying from about half-grown to full-grown were exposed to the adult parasites, but there was no indication of oviposition, and no parasites were reared.

The *Apanteles* larva, or grub, is about 3 mm. to 4 mm. in length. The number that may develop in a borer larva varies, a maximum of 40 having been observed. Once free from the host, which they leave in a shriveled condition (Fig. 4, left), the larvæ congregate in a group and move about in search of a place in which to spin their small, white cocoons. The usual place selected is in the upper part of the borer tunnel at a point near its mouth. The cocoons are stuck together in a group, or mass, which conforms to the surface on which it is formed. The groups found in the tunnels are nearly cylindrical in shape and, depending on the number of cocoons, are about one inch long. (See Fig. 4, center).

The length of time required for the larval stage is not known, but a maximum period of 47 days between the time of collection and emergence of the parasite larvæ has been noted during the winter months. The length of time in the pupal, or cocoon, stage has varied from 10 to 12 days, 11 days being

the average time observed during October and February. Adult life in confinement is comparatively short, but some adults have been observed to live about two weeks under laboratory conditions.

As no secondary parasites or other natural enemies have yet been observed to attack *Apanteles*, it is believed that other natural conditions are accountable for its comparatively limited activity in Cuba. Omitting consideration of the possible food plants of the adults, which have not been investigated, climatic

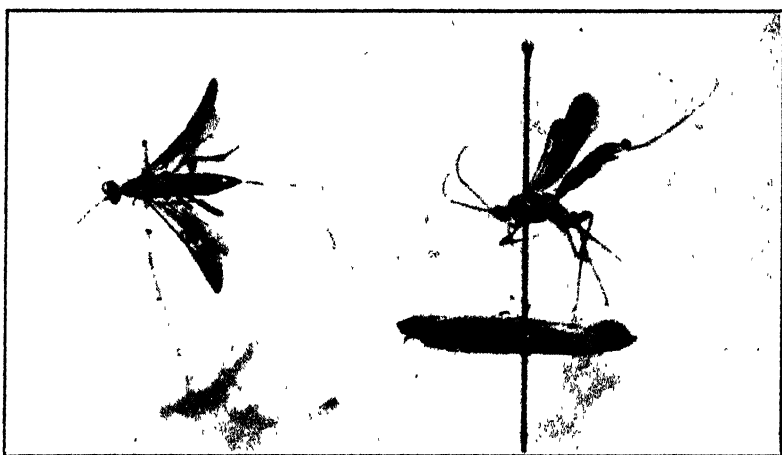


FIG. 5. *Bassus stigmaterus* (Cresson), parasite of the larva of the sugar cane moth stalkborer, enlarged twice. (a) Top view of female, (b) Side view of female and cocoon.

conditions seem to be the most important factors involved. That the greatest parasitism by this species has usually been found during the fall and winter months, which in Cuba are cool and dry, indicates that relatively low temperatures affect *Apanteles* activity more favorably than does rainfall.

The burning of the cane trash delays considerably the appearance of *Apanteles*. In a field burned in February, none of these parasites were found until the cane was about 11 months old, the following January. In an adjacent unburned field, *Apanteles* was recovered 6 months earlier than in the burned field.

During the summer and fall of 1927, 161 groups of cocoons containing living *Apanteles* were sent for colonization purposes

to Mr. T. E. Holloway, in charge of the Sugar Cane Insect Laboratory of the U. S. Bureau of Entomology at New Orleans, La.

***Bassus stigmaterus* (Cresson).⁶**

This parasite has previously been referred to as *Bassus stigmaterus* Cresson (8, 11, 12, 13). However, specimens from the area under observation since been submitted were identified to the U. S. National Museum, by Dr. R. A. Cushman as *Bassus diatraeae* Turner, and this name was used in a subsequent publication (9) to designate this species.⁶

Bassus stigmaterus Cresson (See Fig. 5), has been found principally at one central in the province of Camaguey. In the parasite survey just completed, cocoons were found at one more central in this province and at four centrals in the provinces of Matanzas and Oriente; in addition a living larva was found at one central in the province of Pinar del Rio. (See Table I). Including Holloway's collection record (3, 5) at Central Mercedes, Matanzas Province, reported as *Bassus stigmaterus* Cresson, the known occurrence of this parasite now covers eight centrals in four different provinces. At one central in Camaguey Province living specimens have been found or reared during the months of January, March, May, June, July, and November. (See Table II). It is still considered rare, however, despite the fact that it occurred in some abundance and was quite active at this central during the summer months of 1926 (8). At that time some living pupæ of this parasite were

⁶Order Hymenoptera, family Braconidae.

⁶The Synonymy of *Bassus stigmaterus* (Cresson), by R. A. Cushman, Bureau of Entomology, U. S. Department of Agriculture.

Microdus stigmaterus Cresson, Proc. Ent. Soc. Phila., vol. 4, 1865, p. 65 (Cuba).

Microdus diatraeae Turner, Bul. Ent. Research, vol. 9, pt. 1, 1918, p. 82 (British Guiana).

Microdus crosi Brethes, Revista Ind. and Agric. de Tucuman, vol. 17, 1927, p. 163; Bul. Ent. Res., vol. 18, pt. 2, 1927, p. 205 (Translation into English), (Argentina).

In arriving at this synonymy I have compared five specimens from Cuba with the description of *stigmaterus*, eighteen specimens from British Guiana with that of *diatraeae*, and two specimens from Argentina with that of *crosi*, and have then compared these specimens with each other. All were reared as parasites of *Diatraea*. I find considerable variation in color, especially of the head, the anterior portion of the thorax, and the legs. The sculpture of the basal segments of the abdomen and of the propodeum is also very variable. These variations are not associated with geographical source, the British Guiana specimens displaying practically the entire range in both color and sculpture. Such variations are not unusual in *Bassus*.

sent to Mr. Holloway at the U. S. Sugar Cane Insect Laboratory, New Orleans, La., in an effort made to colonize it there.

Bassus is a larval parasite; but like *Lixophaga*, it sometimes delays its emergence until after the borer has pupated, as the writer has reared it on one occasion from a borer pupa. No observations have been made on egg-laying, either in the laboratory or in the field. The individuals reared thus far have issued from borers that were nearly full-grown, and in 18 days after collection. Not more than one *Bassus* has ever been observed to issue from a single borer larva or pupa. The cocoons (Fig. 5 (b)) were found in about the same locations in the stalks as those of *Apanteles* and the puparium of *Lixophaga*, that is near the exit of the borer tunnel. The length of time in the cocoon stage has been observed to extend over a period of 12 days in November.

All the factors that limit abundance are not known. No secondary parasites have been noted. It is possible that the distribution of food plants of the adult might be of considerable importance. The burning of trash in cane fields appears to be a more serious limiting factor in the case of *Bassus* than of any of the other parasites. During the harvest of 1926-27, the colonia where this parasite was found in abundance in 1926 was swept by a fire which burned all of the trash in most of the harvested fields, as well as a large amount of standing cane. During the following spring and summer no evidence of *Bassus* in this area could be found.

The importance of *Bassus* in borer control is emphasized by the fact that it is active during the summer months when all the other important parasites are less in evidence. This time of the growing season is a critical period in the development of *Diatraea*, inasmuch as it is a period when the cane is growing rapidly and the borer population is almost stationary. As has been shown, *Lixophaga* is active in the spring and *Apanteles* in the fall and winter months. *Bassus* thus seems to supply a chronological sequence in the parasitism of the borer.

***Trichogramma minuta* Riley.⁷**

Although reported by Wolcott (16) and mentioned by Holloway (3) as having been found at Mercedes, Matanzas Province, in 1915 and 1918, this minute parasite (Fig. 6) of the eggs of *Diatraea* and other moths was not encountered in

⁷Order Hymenoptera, family Trichogrammidæ.

the present investigations until recently. During the months of March to July, 1928, and January to May, 1929, collections of borer egg masses from the leaves of young cane were made at 16 centrals widely separated in the provinces of Habana, Matanzas, Santa Clara, Camaguey, and Oriente to determine the range of this parasite. It was found to be present at only 6 centrals, located in the provinces of Matanzas, Camaguey, and Oriente. (See Table I). The egg masses of the borer that yielded parasites constituted from 9% to 100% of the total number collected at these centrals, 31.7% being the average. One mass had only one egg parasitized.

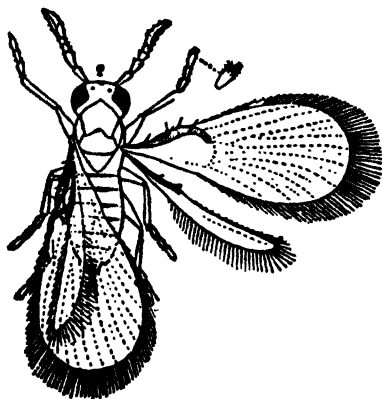


FIG. 6. *Trichogramma minuta* Riley, parasite of the eggs of the sugar cane moth stalkborer, highly magnified. (Riley).

Collections made in March and April, when the cane was about 2 to 4 months old, showed a higher percentage of egg masses parasitized by *Trichogramma* than those made later. None of the eggs collected in July showed any parasitism and no evidence of *Trichogramma* activity has been noted in the fields during the remainder of the season. This apparent inability to prolong early-season activity, and thus to affect the decided increase in borer infestation generally noted during the fall and winter, may be caused by a number of factors, such as the number of *Diatraea* eggs available, their distribution and accessibility, and the presence of alternate *Trichogramma* hosts in the vicinity of the fields. It is evident that the efficiency of *Trichogramma* would also depend largely on whether it parasitized all the eggs in the mass. Although as many as 14 small borers have been found in a single shoot of

young cane, usually only one survived to reach maturity. This one borer is all that is necessary to cause the death or serious injury of the stalk. In older cane, rarely have more than 2 or 3 borers been found in the same stalk, unless it was quite old or very long. Hence, if all the eggs in the mass are not parasitized, the cane stalk will become infested and the larva or larvæ therein reach maturity and damage the stalk. *Trichogramma* will then be killing only those borers which would never have reached maturity under ordinary conditions.

MINOR PARASITES.

In this group are included insects that have been reared from the larvæ and pupæ of *Diatraea saccharalis* and that are of doubtful or little importance in the natural control of the borer.

Sarcophaga sternodontis Townsend.⁸

Sarcophaga sternodontis (Fig. 7) is the most important of the minor parasites of *Diatraea* in Cuba. Van Zwaluwenburg (14, 15) seems to have been the first to record it from Cuba, having reared it from borer pupæ collected in the provinces of Habana and Matanzas during the summer of 1922. The writer has observed it at three centrals located in the provinces of Habana, Camaguey, and Oriente, and it is probably as well distributed as *Lixophaga*. This species of *Sarcophaga* has usually been reared from the borer pupa, but occasionally it has been reared from larvæ that had been injured while being collected in the field. It has been encountered in the field in all months of the year except March, April, November, and December. (See Table II). It is apparently as abundant at one season as another, but the percentage of borers parasitized by it has always been very low. During 1926 and 1927, 90 puparia were collected and sent to Canal Point and Lake Alfred, Florida, for colonization.

The puparium of *Sternodontis* is usually found in the same location as that of *Lixophaga*, from which it can be readily distinguished by the fact that it is larger, not curved, and has two short spines on one end. (See Fig. 7, left, and compare with Fig. 2). The maximum time elapsing between collection and emergence of the maggot was 12 days. The length of time in the pupal stage was about 8 days.

⁸Order Diptera, family Sarcophagidæ.

***Sarcophaga helcis* Townsend⁸**

The species was reared from larvæ of *Diatraea* by the writer on July 24, 1926, and in September, 1927, at Central Jaronù, Camaguey Province. (See Table II). Specimens from these rearings were determined by Dr. J. M. Aldrich of the U. S. National Museum, who stated that "this insect is sometimes parasitic, but more often a scavenger feeding on dead insects." It has never appeared to be very abundant,

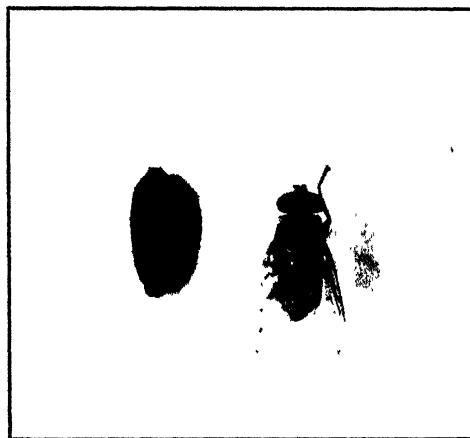


FIG. 7. *Sarcophaga sternodontis* Townsend, parasite of the pupa of the sugar cane moth stalkborer, enlarged twice. Puparium at left.

although it will probably be found in other parts of the Island. The puparia are much smaller than those of *sternodontis*, being about the size of small *Lixophaga* puparia, but are not curved. Sufficient puparia were recovered during the summer of 1927 to send 65 to United States, 12 going to Mr. Holloway at the U. S. Sugar Cane Insect Laboratory at New Orleans and 53 to the Citrus Substation of the Florida Agricultural Experiment Stations at Lake Alfred.

***Sarcophaga surrubea* VDW.⁸**

During the summer and fall of 1927 this species was reared from *Diatraea* larvæ and pupæ that were collected in dead hearts on two colonias at Central Jaronù. (See Table II). It was reared more frequently, however, from borer larvæ

⁸Order Diptera, family Sarcophagidæ.

that had been cut or otherwise injured in collection. Specimens submitted to the U. S. National Museum were determined by Dr. Aldrich as this species. The maximum period of time between collection and emergence was 12 days. The length of time in the pupal stage varied from 4 to 16 days.

***Sarcophaga pedata* Aldrich⁸**

A small number of adults of this species, determined by Dr. Aldrich, emerged in a cage containing both injured and uninjured borer pupæ collected in dead hearts on July 28, 1927. The larvæ issued from the host material on August 9 and 11 and pupated the same day, the adults emerging August 22. This is the only record of the recovery of this species from *Diatraea* in the present work.

***Chaetopsis fluvifrons* Macq.⁹**

The maggot of this species commonly infests the decaying center of cane shoots that have been killed by borers. A maggot was found issuing from a pupa of *Diatraea* collected in a tunnel in a cane stalk by T. S. Ross on May 24, 1927. This maggot subsequently developed into an adult of *Chaetopsis*. The determination was made by Dr. C. T. Greene of the U. S. National Museum. It is not known when or how this maggot entered the borer pupa.

PREDATORY INSECTS.

Only occasionally have any insects been observed to prey on the larva or the pupa of *Diatraea saccharalis* in Cuba. The following species are the only ones that have been found thus far in this work. Altogether they have never been noted to be any considerable factor in borer control.

***Prolabia unidentata* Palis.¹⁰**

***Doru lineare* Esch.¹⁰**

***Anisolabis annulipes* Luc.¹⁰**

***Anisolabis* sp.¹⁰**

These earwigs have been found more frequently in *Diatraea* tunnels than any other predators thus far noted. While found principally at Centrals Jaronù and Baraguá in the province of

⁸Order Diptera, family Sarcophagidæ.

⁹Order Diptera, family Ortalidæ.

¹⁰Order Dermaptera, family Forficulidæ.

Camaguey, they undoubtedly occur commonly in cane fields throughout Cuba. The above species have been determined by A. N. Caudell of the U. S. National Museum.

Prolabia has been observed preying on both the larva and the pupa of the borer, and the other three species on the pupa only, at various periods of the year. (See Table II). Although earwigs have been found in infested cane shoots less than one month old, they were more commonly encountered in cane of 6 months or older. It appears that at this time they can more readily gain entrance to the borer tunnels. In older cane as many as 12.6% of the stalks have been found in a single examination to contain earwigs in the borer tunnels. Usually, however, only about one or two will be found in a hundred stalks. From October to the following February was the period when the largest numbers were found on one colonia during 1927-1928, January being the month of greatest abundance.

***Pyrophorus* spp.¹¹**

Larvæ of at least two distinct species of *Pyrophorus* have been encountered frequently in *Diatraea* tunnels throughout the year. In only a few instances, however, have they been observed to prey on the borer, and in these it was only the pupa that was attacked. (See Table II). The larvæ were about 1 to 1½ inches long, rather stout, and of yellowish color when found. They were sent to the U. S. National Museum and determined by Dr. A. G. Boving.

***Lecon* sp.¹¹**

The larva of another wireworm was found in a small dead cane shoot on May 5, 1927, when the cane was about 2 months old. At first it was thought that it had killed the shoot, which appeared like the ordinary dead heart caused by *Diatraea*; but when submitted for determination, Dr. Boving assigned it to this genus with the note that "this larva is predaceous, feeding on other insects and their larvæ or pupæ."

***Monomorium floricola* Jerd.¹²**

***Solenopsis corticalis* var. *vigula* Forel¹²**

***Prenolepis* sp.¹²**

These three species of small ants, the first and last predominantly dark brown and the second light amber in color,

¹¹Order Coleoptera, family Elateridæ.

¹²Order Hymenoptera, family Formicidæ.

have been noted at various times and places throughout the spring and early fall inhabiting the tunnels made by the borer and feeding on the borer larvæ therein. (See Table II). Twelve other species have been encountered in similar locations, but, except in the case of 3 undetermined species one preying on the larva and two preying on the pupa, complete evidence on their predatory habits was lacking. They all occupy tunnels made in cane of all ages, but tunnels made in dead hearts and very old cane seem to be preferred. The determinations were made by Dr. W. M. Mann, formerly of the U. S. National Museum.

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SOIL ANIMALS INJURIOUS TO SUGARCANE ROOTS.

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For many years the Louisiana Planters have been concerned over a complex of troubles affecting sugarcane roots. In certain fields the plants are stunted, particularly during the second year (stubble cane), can be pulled out of the ground easily, and upon examination the roots appear abnormally reduced in number and size, and are pitted and rotted to an extent that proper nourishment of the parts above ground is impossible. Scientific workers have attributed this "Growth Failure" or "Root Rot" to several distinct causes; Carpenter (1919, 1921), Matz (1920), Earle (1920), Edgerton and Moreland (1920), and Bourne (1922), working in different localities, thought the injury due to fungi of one kind or another. On the other hand Rands (1924) indicted a species of snail (*Zonitoides arboreus* Say) as an important factor, indicating that these molluscs eat pits in the roots and furnish points of initial attack for root rotting fungi.

In July, 1926, the Entomologists of the Louisiana Experiment Station were authorized to investigate further the part played in this Root Rot complex by snails, with the idea of eventually finding means of control for the molluscs, if important, and thereby eliminate the "pitting" and transmission of the fungous rots by the snails. Cooperation was arranged with the Plant Pathologists of the Louisiana Station who were investigating the fungi.

Recent publications by Edgerton and Tims (1927) and Tims and Mills (1927) indicate that species of *Pythium* are responsible for some of the root rot, that there is no correlation between abundance of "pitting" and abundance of snails, and that most of the "pits" do not enter the active stele of the root, but only affect the outer cortex. Also, Muir (1926) and Van Zwaluwenburg (1926, 1927) in Hawaii report "pitting" from *Collembola* (*Isotomodes* sp.) and certain centipedes, and root injury from nematodes. Matz (1920) also reports pitting by species of this last group.

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PRELIMINARY SURVEY.

In taking up this study, it was deemed necessary to make a general survey of affected fields in the different parishes of the Sugarcane Belt of Louisiana. In each locality sugarcane stubbles were dug and with the surrounding soil were examined for snails and other animals, as well as root injury. "Pitting" of the roots was found everywhere and a distinct Cane Root Fauna was brought to light. Table I lists the more abundant of the species found.

TABLE I.
SOIL ANIMALS OF SUGARCANE FIELDS.

Class and Order	Species	Numbers	Stages
Mollusca.....	<i>Zonitoides arboreus</i> Say.....	Many.....	All
Annelida.....	<i>Lumbricus</i> sp.?.....	Few.....	Adult
	<i>Lumbricus</i> sp.?.....	Many.....	Immature
Diplopoda.....	1 species undetermined.....	Few.....	Adult
Chilopoda.....	2 species undetermined.....	Few.....	Adult
Symphyla.....	<i>Symphylella</i> sp.....	Many.....	All
Arachnida.....	3 species of mites.....	Many.....	All
Insecta,			
(Collembola)...	<i>Lepidocyrtus violentus</i> Fols....	Many.....	All
	<i>Orchesella ainsliei</i> Fols.	Many.....	All
	<i>Neanura muscorum</i> Fols.....	Few.....	All
	<i>Proisotoma minuta</i> Tull.....	Many.....	All
	<i>Onychiurus armatus</i> Tull.....	Many.....	All
(Coleoptera)...	<i>Elateridae</i> , species of.....	Several....	Larvæ Adults
	<i>Scarabaeidae</i> , species of.....	Several....	Larvæ Adults
	<i>Ptilodactyla serricollis</i> Say.....	Several....	Larvæ
	<i>Chauliognathus marginatus</i> Fab.	Few.....	Larvæ
	<i>Rhyncophora</i> , species of.....	Few.....	Adults
	<i>Staphylinidae</i> , species of.....	Many.....	Adults
	<i>Carabidae</i> , species of.....	Several....	Adults
(Miscellaneous)	Scavengers		
	Predators		
	Accidental visitants		

EXPERIMENTS IN HYDROMETER JARS, 1927.

The animals procured in the preliminary survey were kept alive, and were used in the first experiments. In the bottom of a number of glass hydrometer jars was placed absorbent cotton to a depth of three inches, with enough water to cover, and the jars were plugged with cotton and were sterilized in the autoclave as in bacteriological work. Pieces of seed-cane (one "eye" each) were treated with hot water (50° C. for one-half hour) and were introduced into the jars with sterile tongs.

Within a few days the cane sprouted and put out roots. The animals were placed in these jars and daily observations were made through the glass with the aid of a binocular microscope, the animals, roots and cane sprouts being plainly visible at all

TABLE II
EXPERIMENTS WITH SOIL ANIMALS IN HYDROMETER JARS, 1927.

Number of Jars	Species	Number of Animals Introduced	Results After Two Months
3	<i>Zonitoides arboreus</i> Say.	18	No pits
1	<i>Symphylella</i> sp	5	No pits
1	Centipedes	3	No pits
1	Mites	Many	No pits
3	<i>Proisotoma minuta</i> Tull	8	No pits
3	<i>Lepidocyrtus violentus</i> Fols	9	Many pits
6	Checks	None	No pits

times. (See Pl. I, Fig. 4). In the two months that this experiment was running, root pitting and other injury was observed, but not in the jars containing snails. The springtail, *Lepidocyrtus violentus* Fols. was frequently seen in the act of eating typical pits in the roots. (Table II).

TABLE III.
SOIL ANIMALS IN PAILS, 1927.

Species	Number of Pails Used	Total Animals Used	Live Animals Recovered	Small Abrasions After 2* (or 3) Months	Results After 2 (or 3) Months
<i>Zonitoides arboreus</i> Say..	7	89	15	3	No pits
<i>Lumbricus</i> sp. (small)	7	130	30	0	No pits
<i>Lumbricus</i> sp. (large).....	4	72	36	14	No pits
<i>Symphylella</i> sp	1	4	0	0	No pits
Centipedes	1	4	2	0	No pits
Millipedes, Brown.....	3	21	0	0	No pits
<i>Lepidocyrtus violentus</i> Fols....	7	208	Many	0	Manypits
<i>Philodactyla</i> larvæ.....	3	30	7	53	No pits
White Grubs (small)	1	4	0	0	No pits
White Grubs (large)....	1	2	2	0	No pits
Fly Larvæ.....	2	9	1	0	No pits
Checks.....	10	0	0	0	No pits

*Where there were several pails containing a single species of soil animal, some pails were examined three months after "inoculation," as well as two months.

The experiments in jars, preliminary in nature and limited in scope, led to a series of tests of the soil animals with cane grown in galvanized pails in the greenhouse. The pails were filled with steam sterilized soil, were planted with hot-water treated seed cane, and the soil animals were added after the cane had germinated, (Fig. 8). A band of tanglefoot confined the animals in the pails, and prevented entrance of undesirable types. (Table III).

The results of the above experiments in pails confirmed the preliminary tests, so it was thought advisable to investigate more thoroughly the group *Collembola*, since the pit-making

TABLE IV.
SOIL ANIMALS IN PAILS, 1928.

Number of Pails	Species ¹	AVERAGE RESULTS AFTER TWO MONTHS			
		Growth of Cane Centimeters		Number Insects Recovered	Number of Pits
		Sprout	Root		
20	<i>Lepidocyrtus violentus</i>	64	273	158	144
3	<i>Onychiurus armatus</i>	79	213	174	30
3	<i>Orchesella ainsliei</i>	70	345	15	0
2	<i>Neanura muscorum</i>	87	216	0	0
1	<i>Proisotoma minuta</i>	0 ²	61	927	9
14	Check	74	238	0	0
5	<i>Symphylella</i> ³	178	1559	20	156

¹Fifty individuals of the species named, introduced into each pail.

²The "eye" failed to start in this pail.

³The average growth figures for *Symphylella* should not be compared with growth in check pails, since these animals were added to pails at a much later date than were the other animals and growth had continued for a longer period.

Lepidocyrtus violentus Fols. belongs to that order of insects. In sugarcane fields *Collembola* of several species were collected in large numbers and were placed in a new series of pails and were handled as were the previous sets.

After a short time, a few pails were "inoculated" with the Symphyid *Symphylella*, because the preliminary tests with this species were too limited in numbers to be conclusive, and also the animals had shown pit-producing tendencies when fed small pieces of sugarcane roots in stender dishes. The results with pails containing *Collembola* and *Symphylella* are given in Table IV.

Root Injury ("Pitting") was produced by the *Collembola Lepidocyrtus violentus*, *Onychiurus armatus* and possibly *Proisotoma minuta*, and also by the Symphylid, *Symphylella*. In making examinations of the roots in these pails, the absence of the fine hairy side roots was strikingly evident in the *Lepidocyrtus* series; in addition to making many pits, the spring-tails ate off practically all of the side roots. This type of injury (named "Root Pruning" for convenience) is considered more serious than the pitting, since absorption of food and water must be greatly hampered by the removal of the secondary roots. (Plate I, Figs. 2 and 3). It will be noticed that the average root length of main roots, per pail, was greater in the *Lepidocyrtus* series than in the check series. This does not signify a stimulation of root growth by the insects, but is a growth response of the main roots, to this almost total destruction of secondary side roots by the springtails.

In the twenty pails containing *Lepidocyrtus*, the cane sprout growth averaged fourteen percent less than in the checks. This is a measure of the damage that might be attributed to the root pruning and root pitting by the spring-tails within an average period of about ten weeks.

In the cases of the pails containing the other animals, the averages should not be compared, as the number of tests is too small. They do, however, show ability or lack of ability of the animal to cause root pitting.

RELATION OF SOIL HUMUS TO ROOT INJURY.

Even though the injury and growth reduction in the pails was not as extreme as often occurs in fields under outdoor conditions, the possibility of lack of humus or other normal food in the pails forcing the animals to attack the roots, was considered. Four sets of pails were prepared, planted, and the animals were added as in previous work, but in one set was used sterilized field soil; in another, the same sterilized field soil with about 20% by bulk of sterilized partly decayed cane "trash" (leaves) added; in another the sterilized field soil with 20% sterilized soybean trash, and the last held unsterilized, air-dried field soil. Examinations after two months (Table V) indicated that an abundance of humus, of such kinds as might be found in fields of sugarcane, did not prevent or even lessen root injury by springtails:

At the present time, field experiments in large drums are being conducted, to ascertain the reduction in growth throughout the season due to the activities of soil animals alone, fungous diseases alone, and the two combined. In another series,

TABLE V.
RELATION OF HUMUS TO ROOT PITTING.

Number of Pails Averaged	Species*	AVERAGE RESULTS AFTER TWO MONTHS			
		Growth in Centimeters		Insects Recovered	Number of Pits
		Sprouts	Roots		
SERIES A. STERILIZED FIELD SOIL.					
13	<i>L. violentus</i> ..	61	250	143	134
1	<i>O. armatus</i>	71	156	321	45
1	<i>O. ainsliei</i>	50	109	40	0
1	<i>N. muscorum</i>	94	226	0	1
5	Check.....	80	220	0	0
SERIES B. STERILIZED SOIL AND CANE TRASH.					
4	<i>L. violentus</i>	71	182	288	201
1	<i>O. armatus</i>	63	174	170	29
1	<i>O. ainsliei</i>	75	347	2	0
1	<i>P. minuta</i>	0	61	927	9
2	Check.....	94	199	0	0
SERIES C. STERILIZED FIELD SOIL AND SOYBEAN TRASH.					
3	<i>L. violentus</i>	66	491	51	111
1	<i>O. armatus</i>	104	309	31	16
1	<i>O. ainsliei</i>	86	580	3	0
1	<i>N. muscorum</i>	94	226	0	1
2	Check.....	31	187	0	0
SERIES D. UNSTERILIZED AIR-DRIED FIELD SOIL.					
4	<i>L. violentus</i>	104	492	15	33
2	<i>O. armatus</i>	86	383	96	22
1	Check.....	97	842	0	0

*Fifty individuals in each pail.

applications of promising soil insecticides are also being made to sugarcane growing under plantation conditions.

The authors wish to express their thanks to Dr. W. E. Hinds who has made many helpful suggestions, to Dr. J. W. Folsom for identifying the *Collembola* and aiding in bibliographical work, and to Dr. C. W. Edgerton, Dr. E. C. Tims

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SUMMARY

1. Root injury to sugarcane by soil animals is prevalent in all of the sugarcane parishes of Louisiana. Extensive examinations of roots and adjacent soil have disclosed a distinct group of "Sugarcane Soil Animals."

2. Experiments with soil animals in hydrometer jars and pails containing growing sugarcane have demonstrated that the root injury known as "pitting" is due principally to feeding activities of the Collembolans *Lepidocyrtus violentus* Fols., *Onychiurus armatus* Tull., and to a less extent by *Proisotoma minuta* Tull., and possibly *Neanura muscorum* Fols. Extensive "pitting" has been produced experimentally also by the Symphylid, *Symphylella* sp., but the Springtail *Orchesella ainsliei* Fols., and the snail *Zonitoides arboreus* Say and other members of the soil animal group did not pit the roots.

3. A type of root injury apparently more serious to the plants than pitting was observed, especially in experimental pails containing *Lepidocyrtus violentus* Fols. This injury has been named "Root Pruning," and consists of the almost total destruction of the secondary branch roots, by the feeding activities of this springtail.

4. In one test, with numbers of pails sufficient to give dependable averages, sugarcane sprout growth was reduced fourteen percent in the first eight or ten weeks in pails containing *Lepidocyrtus violentus* Fols., as compared with similar pails in which there were no springtails.

5. The presence of an abundance of humus in greenhouse experiments with the springtails in pails, did not prevent injury to sugarcane roots.

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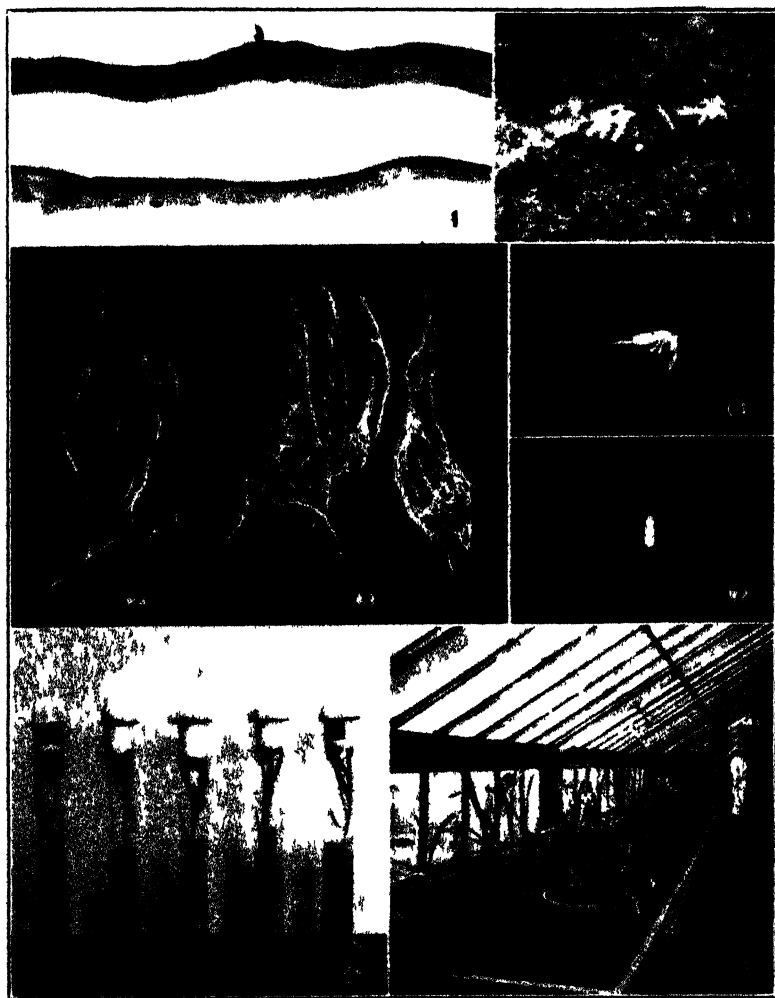
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EXPLANATION OF PLATE.

SOIL ANIMALS INJURIOUS TO SUGARCANE ROOTS.

- Fig. 1. Roots of sugarcane from field, showing pits produced by soil animals. (Photograph courtesy of Dr. C. W. Edgerton)
- Fig. 2. Roots of sugarcane grown in greenhouse in pail in which were many specimens of the springtail *Lepidocyrtus violentus* Folsom.
- Fig. 3. Roots of sugarcane from a similar pail, not containing springtails.
- Fig. 4. Hydrometer jars in which pieces of sugarcane were grown, to observe feeding activities of various soil animals.
- Fig. 5. Young specimens of *Symphylella* sp., and one egg unhatched, in "nest" in soil, greatly enlarged.
- Fig. 6. Adult *Lepidocyrtus violentus* Folsom, much enlarged.
- Fig. 7. Adult *Onychiurus armatus* Tull., greatly enlarged.
- Fig. 8. Sugarcane growing in pails of sterilized soil, containing soil animals.



THE REARING OF DRAGONFLIES FROM EGGS.*

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In working out the life history of certain trematode parasites which occur as adults in vertebrate animals it was necessary to rear parasite-free dragonflies which serve as intermediate hosts in the life history. Since parasitologists have to rear hosts which are free from certain kinds of parasites at least, it makes the problems of food and feeding more difficult. The literature on the subject of rearing common, well-known species of invertebrate animals in the laboratory is scarce and there is an increasing demand for such knowledge; so that the author deems it worth while to make this information available. The following excerpts are from Needham and Heywood ('29, p. 239): "Some eggs obtained in September at Ithaca hatched the following January, having been kept the while in a laboratory of the normal temperature. Doubtless under normal conditions they do not hatch before spring." "Mr. F. R. Nevin has raised vicinum from eggs, laid on October 1 by females from this same pond, which hatched, indoors, from November 28 to January 4 and yielded imagoes on May 3 to May 10, after 11 larval instars."

COLLECTING AND HATCHING.

The species of dragonfly used in this work and which the author had occasion to rear in the laboratory was *Sympetrum obtrusum* Hagen. The eggs were collected while at the University Biological Station during the summer of 1928.

The method of oviposition is of the exophytic type, consequently the eggs are of a rounded form. The average length of the egg of this species is 0.56 mm. and the average diameter 0.49 mm. When the eggs are laid they are of a light yellow color, but later most of them turn dark brown. Some of them retain the color which they have at the time of deposition; in these the progress of development can be observed and the

*Contribution from the Zoological Laboratory and the Biological Station of the University of Michigan.

eggs hatch as well as those which change color. According to Tillyard (1917, p. 227) the species in the genus *Sympetrum* lay their eggs in gelatinous ropes, but such is not true in this species.

Early in the season a locality was found about three miles from the Biological Station, on the shore of Burt Lake, where this species occurred in great numbers. At the height of the season, the middle of August, eggs were collected by catching insects which were *in coitu*.* In obtaining eggs the female was grasped quickly by the wings and if she had not already laid all of her eggs they began to appear very shortly in pairs, side by side, at the genital opening. The eggs were collected by holding a dram vial containing clean tap water or swamp water underneath the insect. Sometimes the eggs were very dry and dropped immediately into the vial. At other times they were somewhat sticky, adhered together, dropped in masses and separated when they struck the water. It appears to me that the males aid the females in egg deposition and that the eggs are dropped while the insect is flying or while resting on sedges. I have never seen them strike the water but they generally fly several feet above it. Tillyard (1917, p. 358) states that in collecting eggs the abdomen of the female is placed in water in the vial. The author was more successful in obtaining eggs by keeping the abdomen of the insect out of water.

The eggs were kept in these uncorked vials for several days, transported to Ann Arbor, Michigan, and there they were transferred to Syracuse watch glasses. Most of them were put into clean water, some into dishes containing mud and water, others into clean sand and water. The watch glasses were stacked or covered to prevent evaporation. Tillyard (1917, p. 358) states emphatically that the water in which the eggs are kept must be dirty or the eggs will mold. Eggs which were kept in clean water hatched the best, the newly hatched nymphs were more easily seen, and could be removed with greater ease than from the other dishes. Fungous growths, to be sure, appeared but did not interfere seriously with hatching; they were kept down in some dishes by changing water occasionally, and to several dishes enough salt was added to make a strong salt solution and the eggs left in it an hour or

*Defined as merely a union of sexes.

so; this I found later did not interfere with hatching but kept down these various growths. Oil appeared on the surface of the water in the dish containing mud and decaying organic material. The water was changed several times on this account. In this connection Tillyard (1917, p. 358) states, "Decaying vegetable matter seems to be essential. I have never succeeded in rearing eggs kept in pure water."

Eggs collected on August 14 and 15, 1928 began to hatch on October 9. I found one nymph in each of three dishes on that morning. Nymphs were removed night and morning. There was no marked difference in the number which hatched at night and the number which hatched during the day. Eggs were kept in the laboratory out of the sun's rays. They continued to hatch until January 30, 1929. According to Tillyard (1917, p. 358) the rounded eggs hatch in from five days to three weeks which seems to indicate that this species is rather exceptional. Some of the eggs were kept in a room which had a temperature of 60° F. or below and they did not continue to hatch any longer than those kept at room temperature or above. The majority of the eggs hatched. Some of the dishes containing eggs which were hatching were put into a cold room kept at a temperature of about 45° F. They ceased to hatch at this temperature and nymphs could be secured when they were wanted by taking the dishes containing eggs into a warm room for a short time. The experiment was concluded when on January 30, 1929, I discovered that the ice machine had failed, the temperature had risen, many eggs had hatched, and most of the nymphs were dead. This happened some time during the month of January. The few remaining eggs continued to hatch until February 27, 1929. At the present time, June 10, 1929, the author has some of these nymphs; they are as strong and transform as well as the others. Eggs collected August 11th and 14th, 1928, were placed in an outdoor, artificial, cement lined pool on November 21, 1928. The pool is small and about eight feet deep. The container for the eggs was made by removing the bottom from a two dram vial and covering each end with three layers of silk cloth. The eggs were removed from the pool on March 18, 1929, one day after the ice had melted. None of the eggs had hatched, but all of the nymphs were out within two days after they were brought into the laboratory.

Nymphs make their escape from the egg very quickly and undergo an ecdysis immediately. I have managed to catch them in various stages of these processes, placed them under microscope, but without removing them from the dish and in every case the nymph made no more progress. It is quite likely that the light effects them or that they cannot be disturbed during this time.

GROWTH

Of nine nymphs on which specific data were kept eight transformed in nine instars* and the remaining one in ten. Tillyard claims that the number of instars for nymphs in general varies from 11 to 15 inclusive. If this is true the number for *Sympetrum obtrusum* Hagen is small. Growth curves which were kept on several nymphs show that the rate of growth increases very rapidly with the increasing number of instars. The average length (twenty-five specimens) of a nymph after the first ecdysis was 1.31 mm., the longest was 1.62 mm., the shortest 1.17 mm. The average length (thirteen nymphs) of a nymph after the second ecdysis was 1.57 mm.; the longest 1.7 mm., the shortest 1.45 mm. The average number of days in the second instar (fifty-one specimens) was six and one-half, the maximum twelve and minimum four and one-half; the average number in the third instar (thirty-four nymphs) was five and one-half, maximum nineteen, minimum four and one-half; the average number in the fourth instar (thirty-nine specimens) was six, maximum eight and one-half, minimum four; the average number in the fifth instar (thirty-four nymphs) was five and one-half; maximum ten, minimum four and one-half. For the sixth, seventh, and eighth instars the figures in their respective order are as follows; seven, nine, five (thirty-two specimens); seven, eight and one-half, six (twenty-six nymphs); eight and one-half, eleven, six (eighteen nymphs). The average number of days between the eighth ecdysis and the transformation (eight specimens) was twenty-one and one-half, the maximum number was twenty-two and one-half, the minimum eighteen. The nymph which required ten instars transformed seventeen days after the last ecdysis. The wide range in the number of days in the third

*I am following Tillyard in considering the pro-nymph as the first larval instar.

instar reflects upon the difficulties in getting suitable food. This is a critical period during which the nymph changes from a diet of *Paramecium* to the nauplius and metanauplius stages of *Cyclops*.

FOOD AND REARING

Nymphs can be reared on two kinds of food but it requires a great deal of patience, time and effort. In this case the nymphs are first fed on *Paramecium* and transferred to tubificid worms (Genus *Tubifex*) in the third instar. In feeding these very small nymphs, the smallest worms have to be cut up and only the ends used in feeding. By adding *Cyclops* to the above foods one has an ideal combination.

For rearing *Paramecium* I employ the method used by Dr. A. E. Woodhead of this laboratory. A very small amount of crumbled dry bread is added to a one-half pint fruit jar, the jar is filled with tap water and inoculated with *Paramecium*, then covered and put on a shelf out of the direct rays of the sun in a rather cool place. For keeping a supply of tubificids I use the method employed by Professor George R. La Rue of this laboratory in his course in laboratory methods. Muck known to contain tubificids is gathered from the shore of a lake or bank of a stream and put in pans which are 18" x 12" x 3". The pans are filled about two-thirds full, and a small continuous stream of water running into the pan keeps the worms sufficiently aerated. About every two weeks it is necessary to bury boiled potato or pieces of raw lettuce cores in the muck. This feeds the worms and concentrates them so that they are easily removed for feeding purposes. Thus they can be kept the year round. The method of rearing cyclops has been more or less of a hit and miss affair so that it is impossible to give a formula, unless one uses the method given later. Dr. D. L. Gamble (1929) gives methods for rearing *Daphnia*, which probably could be used in place of *Cyclops*.

It saves time and trouble to put nymphs in individual containers at the time of hatching, although they may be kept in the same container until about the fourth instar, but after that those nymphs which survive show the scars of many battles. I have reared nymphs until they were half grown in Syracuse watch glasses. When reared in such a limited environ-

ment the water as well as the food must be changed at least every other day. If they are well fed they moult often enough to keep ahead of the fungous growths and protozoans which accumulate on them. A lowered temperature reduces difficulties immensely. Using different kinds of water helps in keeping down these growths; for instance, one day I use tap water; the next, rain water; and then filtered water. A few grains of sand in the dish aid the tiny nymph materially in capturing its prey for without it the impetus of thrusting out of the labium sends the entire nymph back so far that the *Paramecium* or *Cyclops* escapes. Nymphs must not be disturbed during ecdysis or immediately after; if they are they usually do not complete the process or the appendages are crippled. After they are about half grown it is best to put them in large individual containers; two-quart fruit jar is very satisfactory. It is prepared for the nymph by putting two inches of clean water in it, to which is added three or four coarse pieces of grass stems* which have been previously soaked in water so that they sink readily to the bottom. A dry (free from sap) rough weed stem about 3 or 4 mm. in diameter which reaches from the bottom to the top is also added before the nymph is dropped into the container. It is well to clean the sides of the jar thoroughly prior to the time of transformation so that the nymphs cannot climb. If this is not done they climb the wall of the jar to the surface of the water when ready to transform and drown. Growths of filamentous algæ should be removed because the nymphs die or become tangled in them. The top of the jar is covered with a piece of mosquito-netting fastened by a rubber band. Usually the nymphs metamorphose on the stick about three inches above the water (which is usually true in nature although they climb much higher at times) and then climb up and hang from the netting. At other times they climb up and transform on the netting. The water can be poured out through the cloth without disturbing the teneral adult if one is careful. The percentage of successful transformations is greatly increased and the teneral adults live much longer if they are given plenty of food from the time of the last ecdysis until they stop taking it prior to metamorphosis. Teneral specimens

*Dried grass before it is soaked.

have been kept alive four days. The rate of development of the nymph can be retarded by governing the food supply. In doing this, however, it is much better to feed the nymph a small amount daily rather than allowing it to go without food for several days.

If one is not particularly interested in specific data on individuals the nymphs can be reared in the following way without any effort on the part of the keeper and at least seventy-five percent of the nymphs reach the adult state. The two quart jar should be prepared according to the directions above, but in addition to these materials add 15 or 20 cubic centimeters of concentrated *Paramecium* from a clean* culture, six or eight mature *Cyclops* (preferably those which bear egg sacs), and finally the newly hatched nymph. Keep the nymph in a cool place.† It is well to cover the jar to prevent evaporation. By this method a natural food chain is established which is supported by the pieces of grass stems. During the early stages of development the nymph is aided in keeping itself clean, no doubt, by the mature *Cyclops* for they may be seen apparently feeding on the surface of the nymph. It is well to watch the jars because sometimes they have to be replenished by adding *Paramecium*.

The nymph can be removed from the container by shaking it and pouring the contents out into a suitable receptacle. This does not injure the nymph for they can stand rough treatment. Tillyard (1917, p. 358) says that the nymphs should be handled with a camel's hair brush. This is slow and tedious. A very small nymph is easily and quickly handled without injury by picking it up with a pipette which has a suitable opening. Older nymphs can be handled by the legs with a pair of fine forceps. An instrument still better for handling nymphs of all sizes is made by making a loop three-fourths of an inch in diameter from coarse copper wire. Twist the ends of the piece of wire together for a handle and make it as long as desired. Stretch a piece of coarse bolting cloth across the loop and sew it to the wire. Since the frame is made

*It is absolutely essential that one gets the minimum amount of organic material and it is therefore best to take *Paramecium* with a pipette from the regions in the culture where they are most concentrated.

†I have been keeping them in a room which during the winter months has a temperature of about 60° F. during the day; it gets much colder at night, but never freezes.

out of copper wire the angle of the loop in relation to the handle can be changed to suit particular needs.

In rearing nymphs a number of different methods have been tried which include different kinds of containers, and different kinds of foods but the methods described above have given the best results and, no doubt, they can be used very well on many of the smaller forms.

I wish here to express my grateful appreciation to Professor Clarence H. Kennedy, Ohio State University, who has given me information concerning the bibliography and methods of feeding and handling dragonfly nymphs; to Dr. C. Francis Byers, University of Florida, for the identification of specimens; and to Professor Paul S. Welch and Professor George R. La Rue for suggestions in the preparation of this paper.

NOTE.—Since this paper was sent to the editor an article by Nevin on the "Larval Development of *Sympetrum vicinum*," (Trans. Amer. Ent. Soc. 55: 79-102) has appeared.

Comparison of his data on *vicinum* with mine on *S. obtrusum* shows that the embryonic period is about the same when eggs are kept under similar conditions, and that the period of time during which eggs hatch is much longer for *obtrusum*. The number of instars in *obtrusum* is less; is constant for *vicinum* (four specimens) and variable for *obtrusum* (nine specimens). When more *vicinum* are reared the number of instars may also be found to be variable. In comparing growth curves (unpublished) one notices that the increase in length of the *obtrusum* nymph (three specimens) in the early instars is more gradual than in *vicinum* and that the greatest increase in size takes place in the last instar in which the nymph gets more than one-third of its growth (one specimen). Nevin was unable to collect nymphs of *vicinum* in the spring and early summer from a pond in which they were supposed to occur. I collected nymphs from a pond near Ann Arbor, Michigan, on April 30, 1929. Judging from their size they were in the third instar. They transformed in the laboratory and proved to be *obtrusum*. This fact and my experimental evidence indicate that some of the eggs hatch in the early spring.

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THE NESTING HABITS OF THE BALD-FACED HORNET, *VESPA MACULATA*.

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It is a surprising fact that, despite its wide distribution and the conspicuous size and formidable appearance of both insect and nest, this wasp is comparatively little known. The fact that so little work has been done on the behavior of this species is doubtless due largely to three reasons: first, most investigators are strangely prone to be indifferent to those familiar things about them which they feel everyone knows by hearsay, and thus good material at our very doors is often neglected for something more novel or unknown; second, the formidable attitude of this hornet, and its reputation of long standing, do not invite scientific scrutiny; lastly, their habit of building nests high up out of reach or in positions where a hasty retreat cannot be effected in case one is suddenly overcome by a strange impelling desire to be elsewhere, is not conducive to intellectual calm or physical repose. While the following account gives us only certain phases of the life history of this hornet, it will in some measure fill a gap.

I have been fortunate in finding the opportunity to observe the very early stage of nest-building, when the queen single-handed acted as home-builder, mother and provider, and to follow the process in another nest built so low to the ground that I could approach within a few feet of it.

On an abandoned trestle (Fig. 1) in the old stone-quarry at Wickes, Mo., I chanced to see a queen intently occupied with a protuberance on the under side of a beam. It was the beginning of her new nest. The wasp was bringing in pellets of paper pulp and increasing the size of the nest. It is significant that for the most part she alternated in the application of her pulp; she would bring in a load and apply it to the covering, then take the next load inside the nest, presumably to build combs. The detail records show, however, that this alternation was not infallible; there was, as always, variation in her work.

However, her trips to and fro as she worked were very regular, almost rhythmical, as follows:

- 4:20—Left the nest.
- 4:25—Returned with pulp and went into nest.
- 4:28—Flew away.
- 4:33—Returned with pulp and remained inside 12 minutes.
- 4:45—Flew away.
- 4:52—Returned with pulp, entered for a moment, then came out and applied pulp to cover; then went inside.
- 5:00—Flew away.
- 5:08—Returned with pulp and went inside nest.
- 5:24—Flew out and away.
- 5:30—Returned and went inside for a few seconds; then came out and applied pulp to cover.
- 5:33—Went inside. I had to leave until the next morning, when at
- 7:50—She was spreading a layer of pulp on the cover.
- 7:52—Departed for the fields.
- 7:59—Returned and took pulp into nest.
- 8:10—Flew out and away.
- 8:17—Returned and went inside with pulp. I had to leave until
- 8:43—When she was again found inside.
- 8:45—She left.
- 8:55—Returned and went inside.
- 9:08—Departed.
- 9:15—Returned and went inside for a few seconds; then came out and applied pulp to cover.
- 9:18—Went inside a moment, then flew away.

Thus the number of minutes spent in her trips for getting pulp varied as follows: 5, 5, 7, 8, 6, 7, 7, 8, 7. The number of minutes she spent on applying the pulp to the cover of the nest ran $2\frac{1}{2}$, $2\frac{1}{2}$, 2, $2\frac{1}{2}$. The time she spent at unknown work inside, including the disposition of the pulp which she took in, was 3, 12, $5\frac{1}{2}$, 16, 11 and 15 minutes. Thus the deviations from regularity were practically all in the privacy of her own house, where I dared not be too inquisitive.

This nest was of course made entirely by the queen. Undoubtedly beginnings like this are completely wrecked and made over when they are later enlarged by the workers. A paper cover completely enclosed the tiny combs, and the beginning of another paper covering was apparent; this was being added to from time to time. At first glance one suspected that the complete covering was the first, and the unfinished layer the second covering in the work. By aid of mirrors carefully manipulated during the queen's absence, I examined

the inside of the nest, and the total of what I saw was surprising. There was a little comb of ten cells, very similar to *Polistes*' cells, and at least one egg could be seen attached to one of the walls. Around this hung a curtain of paper about an inch in length. Just outside this circular curtain was a second layer of paper, quite independent of the first and having an average space intervening between this and the first of probably one-quarter inch. This second layer extended down lower than the first, and was one and one-half inches long. The third layer (then the outer complete one) was also absolutely independent of the second, and extended below it, being about

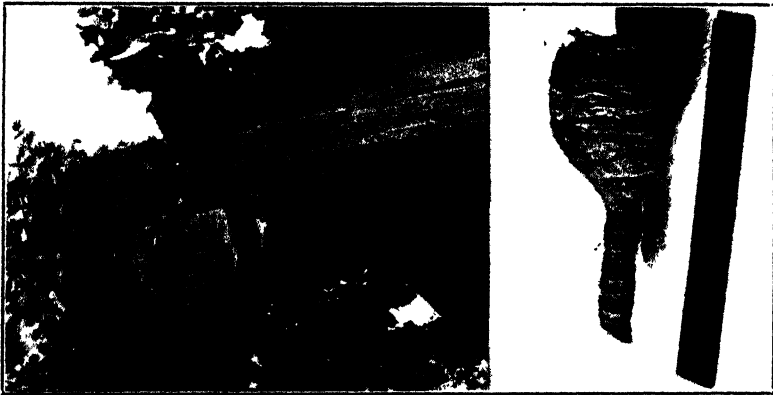
*Figure 1**Figure 2*

Fig. 1. The nest of *Vespa maculata*, the sole work of a queen.

Fig. 2. A close view of the nest shown in Figure 1.

two and one-fourth inches in length. The fourth layer, also separated from the third layer by an intervening space of one-fourth inch, was the incomplete cover at that time, and was only one-half to three-fourths inch long.

It would have gratified me to witness the very first work done on the nest, to learn whether the cells were made first and the cover put on later, or whether the protecting cover was first built and the cells placed later. It would be quite an architectural feat to build a complete circle of pulp and then fit the cells inside. Furthermore, if the work went on at the start as it was being done when it was discovered, with a load of pulp for the cover and then alternately a load for the cells, it would be hard to account for the origin of the instinct leading

to this form of nest. If the cells are made first, one would suspect that this is a *Polistes* habit, with only the addition of the sheets of paper covering; this would put *Polistes* in the position of a more primitive form. If, however, *Vespa* is actually the more primitive, then one must say that the higher form, *Polistes*, has lost this habit.

A pin stuck into the unfinished cover on the occasion of the discovery of the nest, May 28, showed on the next visit, June 13, that, as I expected, this cover had been extended completely to envelop the nest, and had even been carried beyond it and narrowed down into a hollow tube with the opening at the bottom (Figs. 1 and 2). This tube was $\frac{1}{2}$ inch in diameter, and $2\frac{1}{2}$ inches in length, beyond the body of the nest. The top layer was, as we have seen above, the fourth covering; at the top of the nest, next to the supporting beam, the fifth layer was at that time being begun. Up to this date no workers were present; the queen was the sole inhabitant and worker.

On the morning of June 18, I found three workers present. A small window was carefully cut in the wall of the nest, to reveal the interior construction. Imagine my surprise when I found that the curtain-like covers 1, 2 and 3 had been entirely removed, and covering number four, with the long tube, was now the only one shielding the combs! The old covers had evidently been rechewed into pulp to finish the fourth cover with its long tube. The number of cells within had increased greatly; many were capped, some had larvæ so far grown that they protruded from their cells. One lone worker remained and for the day and a half when I could watch her during the queen's absence, never left the nest; in fact, she made no attempt to repair the rent. With her foot she often pushed back into their cells the hungry, protruding young. Earlier in the morning, before the queen and two workers were taken. I could see the queen and young workers clearing out the old cells from which these had hatched; in fact my eye was once too close under the tube when a load of wet debris was flung down into it. This occurred at six o'clock in the morning; they began their day's work early.

Since further observation had been spoiled by the failure of the queen to return from her enforced journey, I took the nest. Figure 2 shows the queenly workmanship, alongside a five-inch rule.

Another nest of *V. maculata*, plump and round and about three-fourths full size, and with a thriving colony, was discovered in mid-summer. This was attached to an elm shrub, three feet from the ground, and only a few feet from the road, where many a horse and pedestrian was given a merry chase. Since all of the queens begin nest-building at about the same time in the spring, one can imagine this colony (Fig. 3) as being almost a replica of what the nest in figure 1 would have been on July 21 if I had not taken it. In others words, the story that we may logically deduce from figures 1 and 3 is that

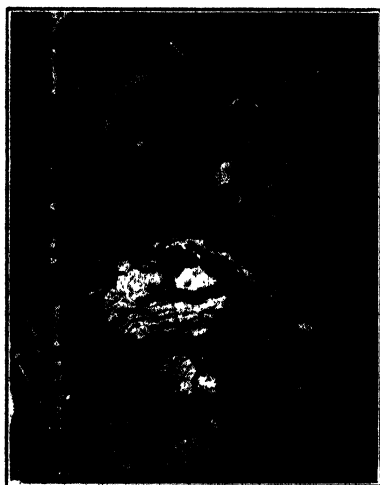


Figure 3

Fig. 3. A half-grown nest of *Vespa maculata* in an elm shrub.

the nest which had on June 18 three newly hatched workers would have grown in thirty-four days to the proportions shown in figure 3 with its populous and active colony

The nest was a-hum with activity; wasps were coming and going, some to the south and southwest, others going north. There were at all times from three to six wasps at the entrance, occasionally one or two at the top near the point of attachment to the twig, and from one to three working on the unfinished covering. This sheet now reached down midway on the nest, and new paper was being added to it. The opening was not at the very bottom as usual, but was about two inches above that point and faced northward. Three layers of paper were visible at the entrance, and these served as a fine floor or

landing platform. The opening itself was about three-fourths inch in diameter.

The wasps which flew in were probably carrying pulp or water, but most of them flashed by so swiftly that one could not see whether they were empty-handed or not. One, which was heavy-laden and traveling more slowly, was carrying in a large brown caterpillar under her body. This was intact, thus dispelling the notion that they carry their food in piece-meal. I could not venture close without causing some commotion. One gave me a slight sting on the arm, the sensations of which lasted about fifteen minutes. The others kept me on the run more times than I care to mention. How these wasps discover an enemy is, in fact, strange and interesting. One can stand still as a stick, thirty-six inches from the nest and watch them fly in over his head or past his face, for a considerable time without attracting the slightest notice. Suddenly one out of the multitude will spy the intruder or in some way sense his presence, and go buzzing around his head in audible circles. It has every opportunity to sting, but it does not do so. If the visitor becomes too ill at ease and begins to run, the disconcerting buzz follows him, seemingly, in "sounds in circles." One can always outrun a sting, as repeated trials have shown; the workers will seldom follow one more than a hundred feet. One often thinks, when watching a nest with impunity despite the fact that workers are passing in and out, that he is unnoticed; suddenly one wasp seems to size up the situation and puts the intruder to flight. It would seem that certain individuals in the nest are especially endowed or trained to be guardians of the home. It is especially surprising to me that the boisterous buzzing going on about one's head at such a time does not attract the whole swarm to join in pursuit. I do suspect that the news is transmitted somehow when the fighter returns, because when I creep up slowly after a flight, I find the doorway crowded with a dozen or more excited individuals, whereas previously only two or three were at the gateway.

It was my privilege to see the first four workers of the first brood emerge from the nest made by the queen alone on June 18, (Figs. 1 and 2). These workers looked exactly like the queen mother and the other workers, only they were of about one-half the normal size of workers; in fact, they more

resembled in size the workers of *V. germanica*. The workers in the large nest were all of about the usual size, or about twice as large as any of the first four which had emerged from the queen's nest. It is a problem yet to be solved, whether size varies with the activities in the nest, or whether the first to emerge are usually small because of their inadequate nutrition that must naturally occur when the queen has all the work to do alone.

At the time of discovery of this nest on the elm shrub, (Fig. 3), the unfinished outer layer of paper extended less than half way down the nest. In three days this entire covering was completed and the beginning of a new one, a ring of paper around the top of the nest and an inch in length, was made. From this one can get an idea of their industry, when one considers the small mouthfuls that they carry at each load and remember that only two or three, and never more than half a dozen, are occupied at paper making at any one time. The secret of their success lies in their ability to make a mouthful spread a long way. With their pliers-like jaws, they pinch the ball of pulp until it makes a thin, narrow strip almost an inch in length. The long hours that they spend at their work and the easy accessibility of their materials are also factors in hastening their work. As the text-books tell us, their pulp is usually made from rotting wood, but I have seen a few taking advantage of the supply of ready-made paper with which our modern civilization strews the woods. Of this I am certain, for after the wasps had left, the spots showed clearly where the material had been freshly scraped away.

By September 2, this nest had increased noticeably in size and strength of colony. During the night, I removed it, in order to get an accurate census of the population and an account of the nest as it was at that time. Under cover of the darkness, and armed with a scrub-bucket, a gunny-sack, a rope, a knife and a cord, and with a small son to assist, we made our way down the rocky hillside through the woods for a mile, to where the hornets were in calm repose.

Now when one examines a hornets' nest at night, one finds the outside clear of guards, but just within a few may be seen, which emerge drowsily at the first gleam of the flashlight, but they do not give the alarm. I approached the nest stealthily and stood for many minutes pondering just what course to

follow. To stand thus, moment after moment in the very presence of so powerful a population, where one would never think of approaching during waking hours, is in itself an event not without emotions of its own. The portrayal of the tense moments of anticipation and self-compulsion, I shall leave to Lady Macbeth: "But what hath made them drunk hath made me bold! * * Infirm of purpose! Give me the daggers!" I carefully survey the structure of the nest, and note that it is attached by three twigs; I will cut two of them, and when the suspicions of the disturbed sleepers have again subsided, I will place the pail beneath, cut the third twig and run, and when I return with sack and cord, I shall find them snug within the pail. I signal to the boy to go down the road about fifty feet with the lantern, and by the aid of my flashlight I cautiously snip the first twig. An explosion of buzzing occurs within; many come to the aperture and crawl outside, while the buzzing within swells like the rising wind before a sudden storm. I darken the flashlight and wait * * * More emotions. * * Who ever said that time has wings? * * Why *will* that bucket handle rattle so? Crackle! Here through the underbrush comes an inquisitive dog to greet us—confound that pup! The deep rumble within fitfully subsides. I cut the second twig. The great ball quivers for a moment while the occupants, already alert, pour out of the aperture like hot lava from a crater. Crash! The remaining twig breaks under the ponderous load, and the mass crashes to the ground! Both the hornets and I were then guided by pure instinct; the dog was more faithful to his investigations—alas!

Having eventually discovered myself somewhere down the road, I began considering how to finish the task. Stealthily slipping the lantern back near to the scene of the disaster, so that the stragglers could see to return to the nest, we walked again to headquarters and obtained a rake, and an hour later with perfect ease I raked the mass into the bucket, covered it with the sack, and carried all back to the city on the train the next day amid calm and unsuspecting fellow passengers.

There are important details which need to be mentioned here. The next morning when I went to examine the site, I found that in rolling the nest with the rake, a piece of the outside layer of paper about as large as one's two hands, had been torn off and lay on the vegetation three inches from the

ground, and that about fifteen very vicious workers that had been left behind or had been out all night, were clinging to the under side of this remnant of what had been their home. I was delighted to find, upon returning exactly a month later, October 2, that this remnant of the colony had constructed a new nest, using as a foundation this one sheet of paper, supported on a bed of weeds, three inches from the ground. This nest was very different from the former one in both shape and size. The original sheet had been used as the roof and the nest had been built below it. This work was undoubtedly the achievement of the workers only, because the young queens were not abundant in the nest, and in the small combs within this second nest, which I shall later describe, only a few larvæ were in evidence and they had all died while they were very small. No queens were found in the nest on the occasion of this second visit, and only ten workers remained. It seems unlikely that unfertilized queens* could or would build nests of a different type of architecture from that usually followed by the species. This nest displayed paper material in more than half a dozen shades of grays and browns, and at the point where I had cut a window in the wall there were six layers of covering. The interior was very irregular, showing bumps and lumps, due to the fact that the wasps made the best use they could of the foundations which they had at hand. The opening to the nest was only a tear made by the rake in the original scrap of paper, and was a very crude aperture. One can hardly give the dimensions of this shapeless mass.

Not satisfied with making for themselves a shelter only, these industrious workers had made two combs of shallow cells, one with 12 cells, which was fastened to the ceiling of the nest and one with 10 very small cups; the latter cluster had fallen to the floor of the nest, but in three of its cells were tiny dead larvæ.

The accidental experimentation reveals the plasticity of these creatures; if they have no home, they make one, even though the season be near the end. If they have no twig, they make good use of a weed or any available material; and since the workers carry eggs, they build combs, lay eggs and try to rehabilitate the colony.

*No males were in the nest when it was taken on September 2.

The entire mass of the first nest was taken home and etherized; care was taken to see that all the adults died under the ether, but the young in the capped cells were uninjured. The nest with these sealed cells was placed in a breeding cage and from it healthy adults emerged from time to time. Those which emerged were kept alive by feeding upon molasses, grape jelly and canteloupe; when water was sprinkled upon the nest, they lapped up great quantities of it. A census of the adults in the nest on September 2 was as follows:

Killed adults, workers.	220
Killed adults, queens.....	34
Workers left behind.....	15

Total population, September 2..... 269

There were four tiers of combs in the nest; the lowermost was the smallest, with only 12 cells, 8 of which had eggs. The cells of the other tiers could not be counted without the utter destruction of the nest, but I could see that the third tier contained 51 sealed cells, and the second a considerable number. During the next thirty days, adults emerged from these capped cells to the number of 88 workers, 52 males and 85 queens. This gave us an entire adult population at the end of the season of 494, of which 24 per cent were queens. It is true that in their natural environment, a number of the larvæ would have been brought to maturity. Our first deduction is that this would have increased the population; very probably, however, some of the adults would have died during the interval, so one is justified in assuming that the number 494 is approximately correct for this nest at the end of the season.

With almost all nature books telling us that in the autumn both males and queens are born, it is highly interesting to review the figures of the census given above to find out just when the reproducing organisms come upon the scene. These figures show that on September 2, when the entire population was anaesthetized, there were absolutely no males—only workers and queens; evidently the latter were just beginning to appear. But during the next thirty days the adults that emerged from the capped cells numbered 225, of which 85 were queens and 52 were males. It showed at least that the queens emerge earlier than the males, which is somewhat different from the condition in most insect life, since in many

solitary species priority in male emergence occurs. It also shows that the nest as a whole gave birth to 119 queens and only 52 males. This disproportion of the sexes is, however, probably due to the fact that the combs contained many larvæ which died under the severe conditions of being caged, and, since the males were the last to emerge, a greater proportion of the larvæ that died were naturally those that under natural conditions would have developed into males. This would have equalized the sexes, or perhaps left the males predominating.

I have no way of knowing how long the new queens had been out, but I often wonder if it is not possible (although perhaps improbable) for these virgin queens to oviposit in the cells and thus produce males before the end of the season. I do not fully know the literature on this subject, but it seems to me that this explanation of parthenogenesis is just as logical as the explanation that a fertilized female can, by contortions or otherwise, pass from her body eggs which have escaped contact with the fertilizing element. Of course this can in part be proven in a future season by examining the abdominal contents of a few queens in the fall to ascertain if they contain mature eggs at that season.

A later examination and dismemberment of the nest revealed that the number of cells in the four combs was as follows:

<i>Tier</i>	<i>Old or Capped Cells</i>	<i>Total Cells</i>
First or top comb.....	375	375
Second.....	380	572
Third.....	54	180
Fourth or lowermost.....	0	12
	809	1,139

These figures are of interest in showing that the number of cells built was 1139, of which 340 were new and too small at the end of the season to have permitted an adult to come to maturity, while 809 cells gave strong evidence of having brought at least one occupant to maturity. I did not make careful count of how often cells were used a second time, but we know that from these 809 cells there remained at the end of the season a population of 494. ■■

It is often remarked that cells are used more than once; this can easily be ascertained in this way. The larva feeds

during its life and carries the excrement in its body until just prior to pupation, when it ejects it all at one time; since the larva hangs head downward, this material is plastered against the roof by movements of the body, and eventually hardens into a reddish-brown, gritty substance. By counting the number of layers, one can easily tell the number of occupants of a given cell. This same statement applies to certain and probably all species of *Polistes*. Unfortunately, this examination of the layers of excrement in the cells of this nest was delayed until too late; the dermestes larvæ had so far destroyed the cells as to make counting impossible.



Figure 4

Figure 5

Fig. 4. A nest of *Vespa maculata* with covering removed to show the combs

Fig. 5. The attic in the nest of *Vespa maculata*

Not all that are born survive, and despite the formidable demeanor of these hornets, we have some records of their falling prey to other animals. Bilsing* fed *V. maculata* to the spider, *Phidippus audax*, and Bromley† records that this wasp was preyed upon by the robber-fly, *Proctacanthus philadelphicus*. We know they are persecuted by man wherever he has the courage to attack them, but we are surprised to learn that in some places men also eagerly gather all they can find for food. Cowan‡ tells us that the Creoles of Mauritius eat the larvæ of these wasps, after having roasted them in the combs. In taking the nests, they drive off the adult wasps by means of a burning rag fastened to the end of a stick. "The combs were,

*Ohio Journ. Sci. 20: 257. 1920.

†Psyche 21: 194. 1914.

‡Curious Facts in the History of Insects. 1865.

at his time of writing, offered for sale at the bazaar of Port Louis."

It is interesting to note that the large cells from which the queens had emerged were not isolated, but were scattered promiscuously throughout the two central combs. Several of them gave evidences of being old cells now reoccupied. The same condition was found in another large nest which had three tiers of cells, and in all three were the large cells of the queens scattered at random among the others, showing also old cells reused. Some of these larger cells may be seen in the three tiers shown in the illustration; (Fig. 4), here one wall is cut away to reveal the inner structure and the six layers of paper in the covering.

The queens of *V. maculata* do not hibernate in the old nest, but find shelter for the winter elsewhere. On October 22, 1922, two females of this wasp were found hibernating under a log. Each was in a small cavity in the under side of the log; they were about three feet apart.

When one walks into the woods and sees high up among the branches a nest of *V. maculata* swinging lightly with the breezes and resembling some huge tropical fruit, (Fig. 10), one scarcely realizes that it has the stability to withstand the vicissitudes of the weather. But these artisans build strong, as the few details below will show.

The first comb is very securely fastened on a stout twig, and between the roof of the comb and outside paper covering is a mass of stout, irregular layers that hold this comb to the twig by the increased strength of many points of attachment, both to the twig and to the nest. This somewhat resembles corrugated cardboard (a cross-section may be seen in figure 5; it combines lightness with strength, but its main feature is its rigidity. Regardless of how the wind and weather may tear the outer cover, this first comb is anchored rigidly to the twig and the safety of the young in the cells is assured; it is a small matter to repair a rent in the roof. Before going on with further details of this nest, I want to introduce a photograph (Fig. 6) of a last season's nest just as it was removed from the tree. This nest had survived the rigors of a Missouri winter. The covering was torn and tattered but the combs adhered securely to the twigs. This demonstrates the advantage of their type of building. Many people have the notion that the

combs adhere loosely to the interior of the paper walls, but an inspection of the interior of any nest proves the contrary.

The reinforcing layer which is built in between the top comb and the support varies in thickness; while in some places it is as thin as the sheets that go to make the outside covers, other portions are so thick as to be rigid and brittle. Very often the nest is built around the branch, so that the lower combs also benefit by having a point of attachment, though this is not always the case. But whether or not they have this advantage, the lower combs are always attached to the one above by stout ridges on the roof of the comb. The amount



Figure 6

Figure 7

Fig. 6. A last year's weather-beaten nest of *Vespa maculata*.

Fig. 7. A nest of *Vespa maculata* abandoned before it had attained more than a fourth of its full size.

of such attachment varies according to whether or not they have a twig also for their support. Figure 8 shows the roof of a middle comb and these ridges which fastened it to the comb above; the irregularity of the ridges is due to the fact that the point of attachment to the comb above is always among the cells containing living organisms, and these supports follow a zigzag course so as to come between the cells, instead of blocking some poor creature's doorway. These ridges are massive, and I believe any colony would find it advantageous to build in such a way that a twig would penetrate all the combs and thus save much building of ridges.

While one expects to see these nests hanging from branches—and I have never seen a full-grown one that did not—I have

seen four or five small and abandoned ones in other situations, such as the eaves of buildings. While the one in figure 2 would probably have come to maturity if it had not been disturbed, those in the caves were in such narrow places that full growth would have been utterly impossible, and hence they were abandoned in an early stage. I suspect further that their existence is not always a rosy one. One nest (Fig. 7) was found in the autumn, attached to a twig but abandoned when

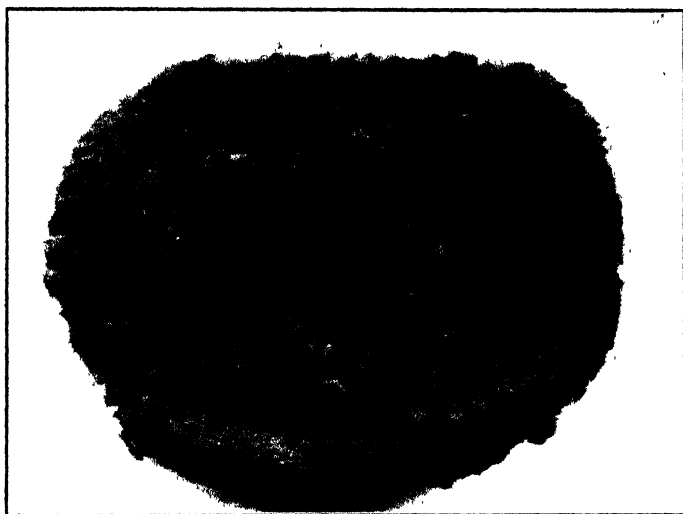


Figure 8

Fig. 8. The comb of *Vespa maculata* showing the stout ridges by which it is fastened to the comb above.

only about one-fourth full size; we can only surmise that some disaster had befallen the builders to cause them to abandon the nest, or that this group had had the same history as that recorded for the fifteen workers and a remnant of paper.

One very often reads, especially in English publications, that certain years are favorable wasp years and others are not. The writers often attribute this to the wet or dry condition of the spring, asserting that wet weather early in the season causes much mortality to the queens before the colony is safely founded. All of the observations herein recorded were made at Wickes, Mo., in 1920. I spent much of the summer of 1917 and 1918 at this place and made it my business to look

for these nests, since in all the days of my life I had never seen a hornets' nest in its natural position. In these two years, none were found, although occasionally workers were seen on the wing. In 1919 I was kept in the city, but in 1920 when I again got to Wickes, I discovered during the summer half a dozen live nests and about the same number of old nests, more or less dilapidated. In 1921, a careful search revealed no new nests, although early in the season a number of queens were seen.



Figure 9

Figure 10

Fig. 9. A well concealed nest of *Vespa maculata* in an apple tree.

Fig. 10. A nest of *Vespa maculata* swinging in the tree tops.

Now I firmly believe that weather is one factor in determining the frequency of these wasps. I wish to add, however, that I believe the abundance of fruit is a very important factor which should not be left out of consideration. In England, these insects are destroyed in great numbers because of the injury they inflict on the ripening fruit. In 1919, our region enjoyed the greatest fruit crop that had occurred for several years; in 1920, the fruit crop was fair; in 1921, the frost killed everything, so that in this entire region not even a persimmon or a pawpaw could be found. This correlates nicely with the occurrence of *V. maculata*. Cold is also a factor influencing the population by shortening the duration of their lives. This point was brought to my attention by the condition of two nests observed on October 13. One was on a hillside facing northwest; this showed no activity, and when I removed it

from the tree with a long pole, only a few soft, newly-dead wasps fell out of it. Three hundred yards from this point, in an apple tree in a sheltered, sunny situation, was another nest which was filled with bustling activity on the same day. I had one of the natives keep watch for me, and he reported that for a week thereafter some bees were seen coming and going from the orchard nest. On October 13th, I noted that the workers that flew in were much smaller than the usual workers, and in size resembled those first four recorded when they emerged in June. This may have been due to the shortage of food at both extremes of the season.

The nests of *V. maculata* are often so hidden by foliage that it is a wonder that even the workers themselves can find them. Figure 3 shows a nest among the foliage, with the lights and shadows blending nicely to protect it in its mottled gray; the foliage in front of the nest was cut away during the night to expose it for photographing. Figure 9 shows a nest nicely protected among the foliage of an apple tree; it is quite large, with only a small portion visible. But why the nests should need to be protected, I cannot for the life of me see! Perhaps, however, these little fellow citizens of our planet have specialized so excessively on their defense that their defiance is a boomerang which brings back the wrath of other creatures upon them and leads to their destruction. Thus in the end these bold and formidable warriors never rise, in permanent population, above the butterflies or song birds. How immutable are Nature's laws of give and take!

AN ANNOTATED LIST OF THE TACHINIDÆ OF MISSISSIPPI.

H. W. ALLEN,

Japanese Beetle Laboratory, Moorestown, N. J.*

This list has been compiled from data on material obtained on several collecting trips in different parts of the State, and from records obtained by rearing parasites from lots of insects received from numerous locations. The work was done between 1920 and 1925, which includes two seasons of intensive study of Tachinidæ at Agricultural and Mechanical College, Mississippi. Acknowledgments are made to Dr. J. M. Aldrich, who has checked the questionable determinations of Tachinidæ and verified the names used, to Dr. J. M. Beal for determinations of plants mentioned, and to the several collectors whose names appear in the list.

The seasonal distribution of adult Tachinid population is probably parallel to the species population as presented in Figure 1. January and the colder parts of February comprise the only period in which adults were not observed. There are two well marked peaks of abundance, as is indicated by the curve for species observed in the field. One is contemporaneous with the maturing of the early spring herbaceous vegetation, and rises to an apex of 23 species listed as occurring in the middle of May; the other occurs at the beginning of the cooler, more humid weather of late summer, and rises to an apex of 50 species in late September. This is considerably greater than the spring peak. The periods of greater abundance are separated by a period during the hot and frequently very dry summer, in which few Tachinidæ can be found in the field.

Within the region studied, Tachinid adults were normally more abundant in moderately dense, succulent, herbaceous vegetation from about one foot to several feet tall, and represented by such aggregations as fields of crimson clover, vetch, cowpeas, cotton, dense weeds, the weedy fringes of woodlands, or even open woods with frequent thickets of weeds and shrubs. Favorable habitats for adults were notably more

*Submitted as a contribution from the Mississippi Agricultural Experiment Station.

widely expanded during the comparatively moist, cool days of spring and fall, but shrank, during the hot, dry summer months, to the edges of swamp forests, or lowlands having a dense protective covering of succulent vegetation. At such times adult Tachinidæ become exceedingly scarce over wide areas of short-grass pasture, grasslands, and cultivated fields, particularly on the poorer upland soils.

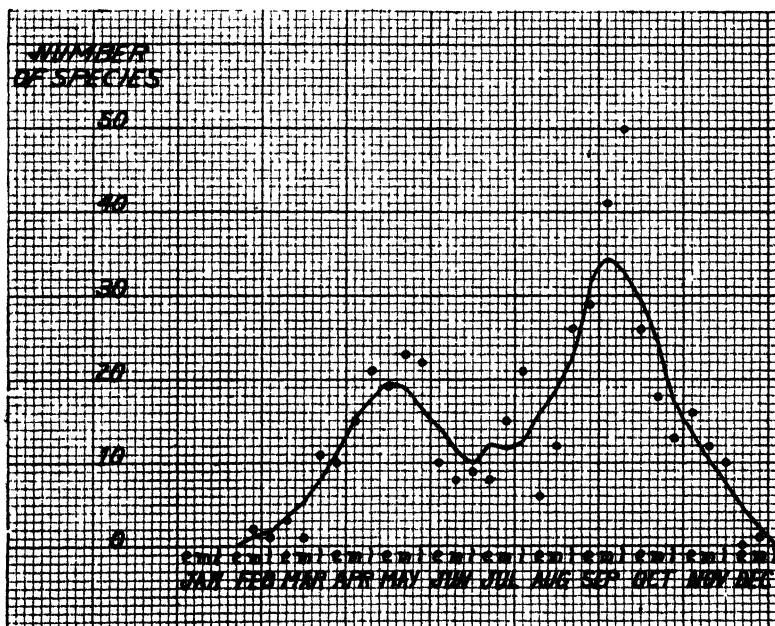


Figure 1. Curve of the distribution of Tachinidæ in Mississippi. Each small circle marks the number of species recorded as present in the adult stage during the portion of the month indicated.

By arranging the species listed into groups according to the seasons in which the adults of these species are known to occur in the state, the following information may be obtained:

Seasons in which adults are present	Number of species present
Spring.....	19
Summer.....	20
Fall.....	14
Spring and fall.....	14
Spring and summer.....	8
Summer and fall.....	20
Spring, summer, and fall.....	26
Total number of species.....	121

TABLE I.
THE FEEDING HABITS OF ADULT TACHINIDÆ.

SPECIES OF TACHINIDÆ UPON WHICH OBSERVATIONS WERE MADE	FLOWERS AT WHICH FEEDING WAS OBSERVED											NECTARIES AT WHICH FEEDING WAS OBSERVED				
	Spirea vanhouttei	Lepidium virginicum	Erigeron sp.	Chaerophyllum tainturieri	Anthemis cotula	Melilotus alba	Rhus glabra	Polygonum pensylvanicum	Polygonum persicarioides	Euphorbia nutans	Bidens aristosa	Chrysanthemum	Stems of cowpea	Stems of smooth vetch	Peach leaves	Honeydew
Proboscis longer than head- height:																
<i>Cistogaster immaculata</i> ...	x	x	x		x							x				
<i>Cistogaster occidua</i> ...			x									x				
<i>Gymnosomma fuliginosa</i> ...			x		x								x			
<i>Phasia diversa</i> ...	x			x								x				
<i>Phasia grandis</i> ...	x															
<i>Phasia nitida</i> ...	x															
<i>Phasia pulvereæ</i> ...																
<i>Phoranthella calypteralis</i>	x		x									x				
<i>Phoranthella occidentalis</i> ..	x		x									x				
<i>Leucostoma</i> sp.										x					x	
<i>Epigrimia polita</i> ...			x													
<i>Siphoclytia robertsoni</i> ...							x									
<i>Plagiomima anomala</i> ...			x													
<i>Bonnetia comia</i> ...									x			x	x	x		
<i>Pyraustomyia penitatis</i>								x								
<i>Cuphorocera furcata</i> ...									x			x				
<i>Copecrypta ruficauda</i> ...	x	x		x		x		x	x	x						
<i>Archylas analis</i> ...	x			x		x		x			x	x		x	x	x
Proboscis as long as head- height:																
<i>Distichona varia</i> ...													x			
<i>Atacia brasiliensis</i> ...									x							
<i>Atacia crassiceps</i> ...									x							
<i>Ernestia ampelæ</i> ...				x												
<i>Phorocera claripennis</i> ...													x			x
<i>Phorocera floridensis</i> ...													x			x
<i>Gonia texensis</i> ...											x					
<i>Gaediopsis flavipes</i> ...									x				x			
<i>Archylas hystrix</i> ...												x	x			x
Proboscis shorter than head-height:																
<i>Myiophasia globosa</i> ...							x									
<i>Lixophaga variabilis</i> ...													x			
<i>Tachino-phyto indecisa</i> ...													x			
<i>Ernia triquetra</i> ...													x			
<i>Metavoria orientalis</i> ...												x	x			
<i>Belvosia bifasciata</i> ...													x			x
<i>Belvosia unifasciata</i> ...								x								
<i>Nemorilla floralis</i> ...																x
<i>Zemilia confinis</i> ...										x			x			
<i>Phorocera loricis</i> ...																x
<i>Exoristoides slossonæ</i> ...													x			
<i>Doryphorophaga doryphora</i>									x							x
<i>Achastoneura archipphivora</i>																
<i>Achastoneura aletia</i> ...													x			
<i>Achastoneura frenchi</i> ...													x			
<i>Achastoneura melalopha</i> ...															x	
<i>Masicera semilis</i> ...													x			
<i>Sturmia distincta</i> ...										x		x	x			x
<i>Sturmia inquisita</i> ...													x			
<i>Winthemia quadripustulata</i> ..										x					x	x
<i>Phytodromia setigera</i> ...																
<i>Paradidyma singularis</i> ...													x			
<i>Pseudochaeta argentifrons</i> ...													x			
<i>Exorista larvarum</i> ...													x			x
Totals.....	8	2	8	4	2	2	2	4	6	5	2	13	26	2	3	14

Further collecting would undoubtedly extend the seasonal distribution of numerous species, thus decreasing the numbers listed for one season, and increasing the number listed for two or three seasons. Although the information is incomplete, two significant points are indicated by the seasonal tabulation of species as given. First, the number of species overlapping from spring into summer was notably less than the numbers of those occurring in the spring or fall only, or overlapping from summer into fall. Second, there was a total of 47 species which were found in the spring, in the fall, or in both spring and fall, but which did not occur during the summer. These two points indicate that there is a distinct cool-season group of Tachinidæ which are not present as adults during mid-summer. This group, however, is outnumbered by the 74 species listed as being present at some time during the summer. The number occurring continuously in spring, summer, and fall slightly exceeds one-fifth of all those listed. As might be expected, this fifth includes a large proportion of species which are dominant not only in Mississippi, but in large areas of eastern North America, such as *Gymnosoma fuliginosa*, *Trichopoda pennipes*, *Myiophasia metallica*, *Lixophaga variabilis*, *Cylindromyia euchenor*, *Phorocera tortricis*, *Achaetoneura archipivora*, *Sturmia distincta*, *Winthemia quadripustulata*, *Exorista larvarum*, *Copecrypta ruficauda*, *Archytas analis*, and others.

When the seasonal distribution of species of a group including the genera *Phorocera*, *Zenillia*, *Achaetoneura*, *Sturmia*, and *Masicera*, which represent the central and dominant nucleus of the family, is compared with that of the species of a group including the Phasiinæ, *Cylindromyia*, *Beskia*, *Xanthomelana*, and *Hemyda*, which are sluggish, bizarre forms, widely different from the central nucleus, some interesting information is obtained. Of the species listed as not occurring during the summer, 11 are of the second group and only 4 are of the first, while of the species listed as occurring in the summer, 21 are of the first group and only 9 are of the second. This suggests for the Phasiinæ and allied sluggish, bizarre forms, a tendency toward segregation in the cooler, moister portions of the growing season, and the domination of the hot, dry, mid-summer period by the more active, generalized, central nucleus of the family.

The food habits of the adult Tachinidæ were noted wherever observed, and are recorded in Table I. There are, roughly

classified, three common sources of food for the adults, flowers, nectaries on stems and leaves, and honeydew. All the flowers that are known to be visited by two or more species of Tachinidæ have been listed in the approximate order in which they bloom. Two common ornamental plants, the hardy chrysanthemum, which blooms in the fall, and *Spirea vanhouttei*, which blooms in the spring, are both visited by many species of Tachinidæ. Certain species of wild flowers, such as *Erigeron*, *Polygonum persicarioides*, and *Euphorbia nutans* are frequented by several Tachinidæ. On the other hand, a number of species, although blooming in great profusion over the region studied, attract Tachinidæ only occasionally or not at all. *Helenium tenuifolium* belongs to this group. Tachinidæ also feed at the nectaries that occur on the stems or leaves of certain plants, such as those at the bases of peach leaves, on the stems of smooth vetch, and on the fruiting stems of cowpeas. The nectaries of cowpeas attract Tachinidæ in vast numbers at the peak of their abundance in late summer, 28 different species having been observed feeding there and as many as 15 species simultaneously in the same field. Certain aphids and scale insects also, which produce a copious flow of honeydew, are attended by large numbers of Tachinidæ.

Tachinidæ may be divided roughly into two classes on the basis of the food habits of the adult. The first includes those species which habitually visit flowers, and the second includes those which feed at non-floral nectaries or on deposits of honeydew. The difference of habit is associated with a difference in the structure of the proboscis. The habitual flower feeder has a slender, strongly-chitinized, elongate proboscis with a small labella at the tip, well adapted for reaching deeply seated secretions of nectar in flowers. The honeydew and surface-nectary feeder, on the other hand, has a short, stout, more flexible proboscis with a large, fleshy labella, better adapted to feeding from exposed surfaces, but very poorly adapted to sucking nectar from flowers, except in species in which the floral nectaries are poorly protected. The species in Table I have been grouped to indicate the relationship between structure of proboscis and feeding habit. Of the 18 species in which the proboscis is longer than the vertical diameter of the head, 13 have been taken at flowers only, 5 at flowers and also at surface nectaries or honeydew, but none at surface nectaries or honey-

dew or both, exclusively. Of the 22 species in which the proboscis is shorter than the vertical diameter of the head, 1 was found feeding at flowers only, 7 at surface nectaries or on honeydew deposits and also at flowers, and 16 at surface nectaries and honeydew deposits only. Of the 9 species in which the proboscis is about as long as the vertical diameter of the head, and in which the adaptation to flower-feeding occurs, though it is not as pronounced as in the first group of 18, 3 were found at surface nectaries or honeydew only, 4 at flowers only, and 2 both from flowers and from surface nectaries or honeydew.

Actual dates of collecting are omitted in the following list, but the month is considered to consist of three nearly equal portions, namely, early (e), middle (m), and late (l). Unless otherwise noted collections were made by the writer, and, unless other localities are specified, all notes refer to Agricultural & Mechanical College. Citations to literature are given thus: (3-20). The numbers in heavy type indicate the total numbers of determined specimens from Mississippi localities, and serve as rough approximations of the comparative abundance of the species.

***Cistogaster immaculata* Macquart.**

Distribution: Tupelo, 1. Sept.; A. & M. College, e. Mar., m. Apr. (F. M. Hull), 1. Apr., 1. May; Starkville, e. June; **13**. *Feeding habits:* attracted to several flowers but most abundant at the flowers of *Erigeron*.

***Cistogaster occidua* (Walker).**

Distribution: Tupelo, 1. Sept.; A. & M. College, e. Apr., m. and 1. May, m. Oct.; **10**.. *Feeding habits:* similar to the preceding species.

***Gymnosoma fuliginosa* R. Desvoidy.**

Distribution: New Albany, 1. Sept.; Tupelo, 1. Sept.; West Point, m. May; A. & M. College, (8-43), m. May, 1. May (M. R. Smith) (F. M. Hull), 1. July (F. M. Hull); **11**.

***Phasia aenovenstris* (Williston).**

Distribution: A. & M. College, 1. Mar., m. May; **2**.

***Phasia diversa* (Coquillett).**

Distribution: A. & M. College, 1. Mar. to m. Apr. (F. M. Hull) (B. A. Dixon) (Allen), e. and m. Nov.; **22**. Common in the spring and fall, but none have been collected from the middle of April to November.

***Phasia grandis* (Coquillett).**

Distribution: A. & M. College, 1. Mar. (F. H. Jones) (Allen), e. Apr.; **6**.

***Phasia nitida* (Coquillett).**

Distribution: A. & M. College, 1. Mar.; **1**.

***Phasia pulverea* (Coquillett).**

Distribution: A. & M. College, m. Nov.; **1**.

Phoranthella calypterata (Coquillett).

Distribution: A. & M. College, e. and 1. Apr., e. May (A. McIntosh), m. May, throughout Nov.; **28**. No females have been taken, and no adults have been observed from late May until November. *Feeding habits:* most common at *Erigeron* in the spring, and at *Chrysanthemum* in the fall. One of the few long-tongued nectar-sucking species that has been observed feeding on honeydew deposits in considerable numbers.

Phoranthella occidentis (Walker).

Distribution: New Albany, 1. Sept.; A. & M. College, 1. Mar., 1. Apr. (E. W. Stafford) (Allen), e. and 1. May, m. and 1. Nov.; **9**. Females far outnumbered the males, and occurred in mixture with males of *calypterata*. *Feeding habits:* the same as the preceding species.

Phoranthella purpurescens Townsend.

Distribution: A. & M. College, 1. Apr., e. May; **2**.

Trichopoda lanipes (Fabricius).

Distribution: A. & M. College, e. May, m. July; **3**.

Trichopoda pennipes (Fabricius).

Distribution: Tupelo, 1. Sept.; A. & M. College, e. May, m. June (J. W. Bailey), m. Aug., m. Sept.; Sellars, m. Sept.; Mississippi, (8-48); **34**. *Habits:* adults have been observed in abundance about summer squashes heavily infested with squash-bugs, during the late afternoon, but were not active in the same locations during the intense light and heat of midday. *Hosts:* occasionally abundant as a parasite of the squash-bug (*Anasa tristis*) and of the leaf-footed bug (*Leptoglossus phyllopus*).

Myiophasia globosa (Townsend).

Distribution: New Albany, 1. Sept.; Tupelo, 1. Sept.; A. & M. College, 1. May, m. and 1. Sept., e. and m. Oct.; **15**. Moderately abundant from 1920 to 1922, but scarce during the three following years. *Hosts:* potato stalk borer (*Trichobaris trinolata* Say) in the seed pods of Jimson weed. Several flies of this species also emerged from cotton bolls infested with the boll weevil (*Anthonomus grandis*), from which probably they had emerged.

Myiophasia metallica (Townsend).

Distribution: Tupelo, 1. Sept.; A. & M. College, m. Apr. (A. McIntosh), e. May, e. Sept., e. and m. Oct.; West Point, m. May; Sessums, e. Aug.; Crawford, e. Aug.; Ocean Springs, e. Sept.; **16**. Abundant in rank herbaceous vegetation during 1920 to 1922, but scarce the next three seasons.

Myiophasia nigrifrons (Townsend).

Distribution: Holly Springs, 1. Sept.; **1**.

Emphanopteryx prisca (Walker).

Distribution: A. & M. College, e. Apr. (F. M. Hull); **1**.

Lispeida palpiger Coquillett.

Distribution: A. & M. College, m. Apr., 1. July; **2**.

Thryptocera americana Townsend.

Distribution: A. & M. College, 1. July, 1. Sept.; **2**. *Habits:* trapped at high window, as if while migrating.

Chaetophleps setosa Coquillett.

Distribution: Holly Springs, 1. Sept.; A. & M. College, 1. Mar., e. May; **5**. *Habits:* this little fly was abundant in an infestation of the striped cucumber-beetle (*Diabrotica vittata* Fabr.), in early May, 1922, where it was observed attacking adult beetles. The flies which were mostly females, were found to remain on the melon foliage near the host throughout the night as well as during the day.

Chaetostigmoptera crassinervis (Walton).

Distribution: A. & M. College, e. May; **1**.

Chaetophlepsis tarsalis Townsend.

Distribution: A. & M. College, m. Apr., 1. Aug., e. Oct.; **3**. *Hosts:* *Autographa* on Cram. on cowpea.

Celatoria diabroticæ (Shimer).

Distribution: A & M. College, m. and 1. Apr., m. (S. Robinson) and 1. May, 1. July, 1. Aug., e. and m. Sept.; Meridian, e. Sept.; **15**. Adults present from early spring to fall, but rarely in abundance. *Habits and hosts:* most frequently encountered on the foliage of bean, potato, and similar crops infested with their hosts, the spotted cucumber-beetle (*Diabrotica duodecimpunctata* Fabr.) and the bean leaf-beetle (*Ceratoma trifurcata* Forst.).

Admontia pergandii Coquillett.

Distribution: A. & M. College, (8-54), 1. Nov. (H. W. Chalkley); **3**.

Aubaeantia assimilis Townsend.

Distribution: A. & M. College, m. July; **1**.

Lixophaga variabilis (Coquillett).

Distribution: Doddsville, 1. July; Scott, 1. July; Rome, 1. July; A. & M. College, e. and m. May, 1. June, throughout July, 1. Aug., e. Sept., e. Oct.; **21**. *Hosts:* reared from *Epiblana strenuana* Wik., a small lepidopterous borer in the stems of ragweed, at A. & M. College, and in 1924, from several lots of garden webworm (*Loxostege similalis* Guen) collected at different localities in the Yazoo Delta section.

Oedematocera gilvipes (Coquillett).

Distribution: A. & M. College, 1. Apr., e. May, m. July, 1. Aug., m. and 1. Sept., m. Oct.; Ocean Springs, e. Sept.; **25**. *Habits:* not generally abundant, but in the late summer of 1922, a considerable number were noted on screened porches, and the windows of college buildings up to 40 feet or more from the ground, and were presumably trapped at such places while migrating.

Tachinophyto indecisa (Townsend).

Distribution: Holly Springs, 1. Sept.; Tupelo, 1. Sept.; Grenada, m. Sept.; Starkville, m. Sept.; A. & M. College, e. Sept., m. Sept. (E. W. Stafford), e. Oct.; Moss Point, e. Sept.; **27**. Encountered in abundance at Moss Point on luxuriant weeds of a neglected garden.

Arrhinomyia barbarta (Coquillett).

Distribution: A. & M. College, 1. Apr.; **1**. On crimson clover.

Paralispe barbarta (Bigot).

Distribution: A. & M. College, 1. Oct.; **1**. *Feeding habits:* taken at the nectaries of cowpea.

Paralispe infernalis Townsend.

Distribution: A. & M. College, 1. Oct. (G. M. Williams); **1**. *Feeding habits:* taken at the nectaries of cowpeas.

Xanthocera clistoides Townsend.

Distribution: A. & M. College, m. Oct.; **1**.

Ervia triquetra (Olivier).

Distribution: A. & M. College, (8-66), e. May (S. Robinson), m. and 1. May, m. June (C. C. Greer), e. and 1. Aug., throughout Sept., e. and m. Oct., 1. Oct. (H. Gladney), e. and m. Nov. (H. Gladney); Mulden, e. June (H. L. Dozier); West Point, m. May; **33**. *Habits:* adults moderately abundant, and occurring in a wide range of habitat. Aside from frequenting the food sources listed in Table I, they have been observed in tall-grass meadows, on young corn, and on the foliage of pecan.

Leskiomima tenera (Wiedemann).

Distribution: Wiggins, (C. E. Pratt); **1**. *Host:* our only specimen was obtained from a breeding cage stocked with pecan case-bearers (*Mineola indiginella nebulella* Riley) from south Mississippi, under circumstances somewhat doubtfully indicating this host relationship.

Leucostoma acuminata Townsend.

Distribution: A. & M. College, e. Oct., m. Nov.; 6. *Hosts:* adults were observed making attacks on *Corizus hyalinus* (Fabr.) heavily infesting a garden weed, *Euphorbia nutans*. *L. acuminata* was subsequently reared from this host.

Leucostoma sp.

Distribution: New Albany, 1. Sept.; Tupelo, 1. Sept.; Starkville. c. June; A. & M. College, 1. May; 5.

Hyalomyodes triangulifera (Loew).

Distribution: A. & M. College, 1. May; 1.

Ormia montana Townsend.

Distribution: A. & M. College, m. May, Sept.; Hattiesburg, m. Oct. (J. W. Champlain); 3.

Cenosoma signifera Van der Wulp.

Distribution: A. & M. College, 1. Mar. (E. W. Stafford), m. June (A. McIntosh); 2.

Hemyda aurata R. Desvoidy.

Distribution: Greenville, m. Sept.; A. & M. College, m. May; Meridian, e. Sept.; 2.

Xanthomelana attripennis Say.

Distribution: Tupelo, 1. Sept.; Rosedale, m. Sept.; A. & M. College, Sept.; 4.

Beskia aelops (Walker).

Distribution: Starkville, e. June; A. & M. College, 1. May, m. Sept.; Ocean Springs, e. Sept.; 4. *Habits:* This brilliantly-marked little fly is occasionally encountered in the spring and fall, in luxuriant weeds and grass in comparatively moist locations. It is noticeably slow and feeble in flight.

Epigrimyia floridensis (Townsend).

Distribution: A. & M. College, 1. Apr., 1. May; 2.

Epigrimyia geniculata (Townsend).

Distribution: A. & M. College, early spring; 3. *Habits:* Reared from undetermined Pyralid or Tortricid larvæ hibernating in a colony under the bark of a dead tree. Emergence was very early, occurring between February 12 and early March.

Epigrimyia polita Townsend.

Distribution: A. & M. College, throughout May; West Point, m. May; 7.

Siphoclytia robertsoni Townsend.

Distribution: A. & M. College, 1. May; 1.

Plagiospherysa parvipalpis (Van der Wulp).

Distribution: Gulfport, e. Sept.; 1. *Habits:* taken on sandy marine beach.

Blapharigena spinulosa (Bigot).

Distribution: A. & M. College, m. May (S. Robinson); 1. *Hosts:* the army worm (*Cirphis unipuncta* Haw.).

Metavoria orientalis Townsend.

Distribution: A. & M. College, 1. Apr., throughout May, 1. June, m. July, 1. Oct.; Moss Point, e. Sept.; 534. *Habits:* adults were found moderately abundant on potato foliage infested with the host. *Hosts:* the tomato worm, (*Protoparce sexta* Johan).

Voria ruralis (Meigen).

Distribution: Holly Springs, 1. Sept.; A. & M. College, 1. Aug.; 2.

Plagiomima anomala (Townsend).

Distribution: A. & M. College, m. Apr., e. Oct.; 2. *Feeding habits:* Observed feeding at the flowers of a wild aster (*Asier exilis*) and of *Erigeron*.

Pseudotractocera lacnosternæ (Townsend).

Distribution: A. & M. College, e. June (H. M. Harris); **1**.

Pseudotractocera mutabilis (Coquillett).

Distribution: A. & M. College, m. July; **1**.

Pseudotractocera neomexicana Townsend.

Distribution: A. & M. College, e. June (H. M. Harris); **1**.

Distichona varia Van der Wulp.

Distribution: Holly Springs, l. Sept.; Tupelo, l. Sept.; Starkville, e. May (J. M. Langston), e. June, l. Sept.; A. & M. College, (8-79), l. Apr., e. and l. May, l. Aug., throughout Sept. e. Nov.; **31**. *Habits:* Adults usually present from early spring until late fall, though not in large numbers. It is most abundant in the fall, feeding at the nectaries of cowpeas.

Atacta braziliensis Schiner.

Distribution: A. & M. College, e. Oct.; Bay Saint Louis, m. Sept.; **2**.

Atacta crassiceps Aldrich.

Distribution: Tupelo, l. Sept., (2-31); A. & M. College, e. Oct.; **2**.

Siphosturmia rostrata (Coquillett)

Distribution: McHenry, m. Sept.; **1**.

Belvosia bifasciata (Fabricius).

Distribution: Grenada, m. Sept.; A. & M. College, (4-31); McHenry, (4-31), e. Sept.; Mississippi, (8-84); **6**. *Feeding habits:* in addition to its visits to several species of flowers, it has been observed feeding on the honeydew of the tulip-tree soft-scale (*Toumeyella liriodendri* Gmel.) in tree-tops 20 or more feet from the ground.

Belvosia borealis Aldrich.

Distribution: A. & M. College, (4-29).

Belvosia semiflava Aldrich.

Distribution: A. & M. College, (4-11).

Belvosia unifasciata (R-Desvoidy).

Distribution: New Albany, l. Sept.; Tupelo, l. Sept.; A. & M. College, l. Mar., e. and m. Apr., l. Sept., and e. Oct.; West York, (4-21); Mississippi, (8-84); **14**. *Habits:* Adults were fairly common in the spring in fields of vetch, and in the fall at the weedy edges of swamp woods or over Johnson-grass meadows.

Cylindromyia dosiades (Walker).

Distribution: Tupelo, l. Sept.; Starkville, e. June; **2**.

Cylindromyia euchenor (Walker).

Distribution: Holly Springs, l. Sept.; Tupelo, l. Sept.; Starkville, e. Apr.; A. & M. College, m. Apr., l. May, l. Aug.; **9**.

Cylindromyia nana (Townsend).

Distribution: McHenry, m. Sept.; **1**.

Cylindromyia vulgaris Aldrich.

Distribution: A. & M. College, l. Aug.; **1**.

Bonnetia comta (Fallen).

Distribution: Grenada, m. Sept.; Tupelo, l. Sept.; A. & M. College, m. and l. Apr., m. May, Sept., e. Oct., e. and m. Nov.; **6**.

Pyraustomyia penitalis (Coquillett).

Distribution: A. & M. College, throughout August, numerous reared specimens; maggots of this species were noted within the host larvæ at Hernando, Holly Springs, Tupelo, Grenada. *Hosts:* A common species of the smartweed borer (*Pyrausta ainsliei* Hein.).

Ernestia ampelus (Walker).

Distribution: A. & M. College, l. Apr., m. Sept. (J. L. Williams); **2**. *Hosts:* the fall webworm (*Hyphantria cunea* Dru.).

Nemorilla floralis Fallen.

Distribution: Holly Springs, 1. Sept.; Grenada, m. Sept.; A. & M. College, e. and 1. July, m. Sept., throughout Oct., m. Nov.; Ocean Springs, e. Sept.; Moss Point, e. Sept.; 9. *Feeding habits:* Observed feeding on honeydew in separate infestations of aphids on corn, melons, and turnips, also seen on cowpeas, though not in the act of feeding. *Hosts:* Reared from the grape leaf-folder (*Desmia funeralis* Hueb.), over an infestation of which the adults were observed active, and from a bud worm of dahlia, *Pyrausta tyralis* Guen.

Zenillia amplexa Coquillett.

Distribution: A. & M. College, m. Oct.; Artesia, 1. Aug.; Meridian, m. Oct.; Pascagoula; Mississippi, (8-100); 1 collected, several reared. *Hosts:* Reared from cocoons of the stinging caterpillar (*Megalopyge opercularis* S. & A.) received from several parts of the state.

Zenillia blanda blanda (Osten Sacken).

Distribution: Holly Springs, 1. Sept.; Adaton, m. Aug.; A. & M. College, 1. July, m. and 1. Aug., m. Sept.; Mississippi, (1-39); 8. *Habits:* Although not common in the field, several adults have been trapped on screened porches or at high windows as if in migration. They have been observed on cowpeas. *Hosts:* the canna leaf-roller (*Calpodex ethlius* Cram.).

Zenillia caesar (Aldrich).

Distribution: A. & M. College, 1. July; 1.

Zenillia confinis (Fallen).

Distribution: Walls, 1. July (T. E. Saunders); Holly Springs, 1. Sept.; Tupelo, 1. Sept.; A. & M. College, Mar., 1. June, e. Oct., e. Nov.; 8. *Hosts:* the cotton square-borer (*Uranotes melinus* Hueb.).

Zenillia eudryæ (Townsend).

Distribution: Greenville, m. Sept.; 1.

Zenillia reclinata Aldrich and Webber.

Distribution: A. & M. College, m. Nov.; 1.

Zenillia setinervis (Coquillett).

Distribution: Meridian, e. Sept.; 1. Taken on cowpeas.

Phorocera claripennis (Macquart).

Distribution: Holly Springs, 1. Sept.; A. & M. College, m. May, m. Sept., e. Oct. (H. M. Harris), m. and 1. Oct., e. Nov.; Woodland, 1. June; Meridian, 1. Aug. (M. L. Grimes); Ocean Springs, e. Sept.; Bay Saint Louis, m. Sept.; Mississippi, (8-102); 25. *Feeding habits:* Adults feed on the honeydew secreted by the corn aphid (*Aphis maidis* Fitch). *Hosts:* the red-humped caterpillar (*Schizura concinna* S. & A.), the yellow-necked caterpillar (*Datana ministra* Dru.), the poplar tent-maker (*Melalopha inclusa* Hueb.), the silver-spotted skipper (*Epargyreus tityrus* Fabr.), and *Apantesis oithona* Str.

Phorocera floridensis Townsend.

Distribution: Beuna Vista, 1. June (S. T. Wing); A. & M. College, m. and 1. June, 1. July, m. Aug., throughout Sept., and Oct., e. and 1. Nov.; West Point, 1. Sept.; Greenwood; 30. *Feeding habits:* Adults feed on the honeydew secreted by the turnip aphid (*Rhopalosiphum pseudobrassica* Davis), and are frequently present in the field in association with those of the preceding species. *Hosts:* *Datana ministra*, *Melalopha inclusa*, *Epargyreus tityrus*, *Apantesis oithona* and *Autographa oo* Cram.

Phorocera leucaniæ Coquillett.

Distribution: A. & M. College, m. and 1. May, e. June, e. Oct.; 5. *Habits:* Adults were observed several times in early summer on hairy vetch and other luxuriant vegetation. *Hosts:* reared in early October from the cotton army worm (*Alabama argillicæ*).

Phorocera noctuiformis Smith

Distribution: A. & M. College, 1. July, 1. Sept.; **3.** *Habits:* Taken from cowpea and trapped at window, 40 feet above the ground.

Phorocera parviteres Aldrich and Webber.

Distribution: A. & M. College, 1. July, 1. Aug.; Moss Point, e. Sept.; **4.** *Habits:* Adults were captured from cowpeas, also from windows 40 feet above the ground, where they had evidently been trapped while migrating.

Phorocera signata Aldrich and Webber

Distribution: A. & M. College, e. Sept. (C. E. Wilson); **1.**

Phorocera sulcata Aldrich and Webber

Distribution: A. & M. College, 1. Aug.; **1.** Taken from cowpeas.

Phorocera tortricis Coquillett

Distribution: Grenada, m. Sept.; Starkville, m. Aug.; A. & M. College, m. May, m. and 1. July, e. Aug., m. and 1. Sept., e. Oct., e. Nov.; Crawford, m. Aug.; Sellars, m. Sept.; Bay Saint Louis, m. Sept.; **30.** *Feeding habits:* Females frequently found feeding at the nectaries of cowpeas, and on one occasion on the honeydew of the corn aphid (*Aphis maidis* Fitch).

Pelecotheca panamensis Townsend.

Distribution: A. & M. College, 1. Aug., m. Sept.; Utica, (8-103); **3.**

Exoristoides slossonæ Coquillett

Distribution: Holly Springs, e. Sept.; Grenada, m. Sept.; Grenada, m. Sept.; A. & M. College, e. Sept.; **4.**

Doryphorophaga doryphoræ (Riley)

Distribution: m. (C. N. Yelverton) and 1. Aug., m. and 1. Sept., e. Oct.; Meridian, e. Sept.; Moss Point, e. Sept.; **8.** *Hosts:* Adults moderately abundant in the fall on the foliage of potatoes infested with the Colorado potato beetle (*Leptinotarsa decemlineata* Say) from which it was reared occasionally.

Xiphomyia texana Reinhard.

Distribution: Holly Springs, 1. Sept.; Tupelo, 1. Sept.; **2.**

Achaetoneura archippivora (Williston)

Distribution: Tupelo, 1. Sept.; Holly Springs, 1. Sept.; Starkville, m. Aug.; A. & M. College, m. June, m. Aug., throughout Sept.; Ocean Springs, e. Sept.; Moss Point, e. Sept.; **46.** *Habits:* Moderately abundant in late summer and early fall, when it was frequently taken at the nectaries of cowpeas, less often on mung beans and feeding on the honeydew of *Aphis gossypii* Glov., on cotton.

Achaetoneura aletiae (Riley).

Distribution: Holly Springs, 1. Sept.; Tupelo, 1. Sept.; Adaton, 1. July; A. & M. College, m. and 1. May, 1. July, 1. Aug., m. and 1. Sept., e. and m. Oct., throughout Nov.; Sellars, m. Sept.; Bay Saint Louis, m. Sept.; Gulfport, e. Oct.; Pascagoula, 1. May; Moss Point, e. Sept.; Mississippi, (8-107); **75.** *Hosts and habits:* (7-188).

Achaetoneura frenchii (Williston).

Distribution: Holly Springs, 1. Sept.; A. & M. College, m. Sept., 1. Oct. (G. R. Williams), e. Nov.; **9.** Not nearly as abundant as *A. aletiae*. *Hosts:* Overwinters in the cocoons of the polyphemus moth (*Telega polyphemus* Cram.).

Achaetoneura melalophæ Allen.

Distribution: A. & M. College, (7-192), m. and 1. Feb., throughout Mar., m. and 1. Apr., throughout July, e. and m. Sept., m. Oct.; **51.** *Hosts and habits:* (7-192).

Frontina rileyi (Williston).

Distribution: Gulfport, e. June (Harmon); **1.** *Hosts:* the orange dog (*Papilio thoas* L.) in south Mississippi.

Lydella eufitchiæ (Townsend).

Distribution: A. & M. College, m. May (F. M. Hull); 1.

Masicera senilis (Meigen).

Distribution: A. & M. College, e. Nov.; 3.

Sturmia albifrons (Walker).

Distribution: Tupelo, 1. Sept.; A. & M. College, m. July, (F. M. Hull), 1. Aug.; 3.

Sturmia distincta (Wiedemann).

Distribution: Holly Springs, 1. Sept.; Tupelo, 1. Sept.; A. & M. College, 1. Apr., e. and m. May, m. and 1. July, e. and 1. Aug., m. and 1. Sept., throughout Oct., e. and m. Nov.; Meridian, e. Sept.; Ripley, 1. Aug. (H. E. Wallace), e. Oct.; Sellars, e. Sept.; Ocean Springs, e. Sept.; Moss Point, e. Sept.; Mississippi, (8-111); 40 collected, many others reared. *Habits:* Adults very abundant in late summer and fall on the nectaries of cowpeas. It occurs in the field, even in mid-day sunlight, at temperatures up to 84° F. and over dry soil at humidities as low as 20 per cent. *Hosts:* An important parasite of tomato worm (*Protoparce sexta*) larvæ in the late summer. A brood of late-fall emerging adults appear after this host has disappeared from the field.

Sturmia inquinata (Van der Wulp).

Distribution: Tupelo, 1. Sept.; A. & M. College, e. and 1. Sept., 1. Oct.; Bay Saint Louis, m. Sept.; Mississippi, (8-111); 7.

Sturmia limita Coquillett.

Distribution: Tupelo, 1. Sept.; A. & M. College, 1. Apr.; 3. Males have been collected from hairy vetch in bloom.

Sturmia occidentalis Coquillett.

Distribution: A. & M. College, e. Apr.; 1.

Sturmia phycoides Coquillett.

Distribution: New Albany, 1. Sept.; Tupelo, 1. Sept.; 2.

Winthemia quadripustulata (Fabricius)

Distribution: Holly Springs, 1. Sept.; Tupelo, 1. Sept.; Lamont, 1. May, (J. L. E. Lauderdale); A. & M. College, 1. Mar. (S. Robinson), e. and m. Apr., e. May (F. M. Hull), 1. May, m. and 1. July, e. and m. Aug., m. and 1. Sept., 1. Oct. (F. M. Hull), e. Nov.; Starkville, m. Aug.; Crawford, m. Aug.; Sellars, m. Sept.; several hundred specimens determined. *Hosts:* (5-10). *Feeding habits:* (5-20). One of the commonest Tachinid parasites. Adults are abundant from the middle of April to the middle of October, in a great variety of habitats.

Phytoadmontia setigera (Coquillett).

Distribution: Tupelo, 1. Sept.; A. & M. College, m. May, 1. Sept., e. and m. Oct.; 21. Adults occasionally abundant in the fall.

Paradidyma singularis (Townsend).

Distribution: Holly Springs, 1. Sept.; New Albany, 1. Sept.; Tupelo, 1. Sept.; A. & M. College, (8-126), 1. Apr., 1. Aug.; 16. *Feeding habits:* In late September, 1921, large numbers of adults were observed feeding at the nectaries of cowpeas and on the juices of ripe persimmons which had dropped from the tree.

Acemyia dentata Coquillett.

Distribution: Tupelo, 1. Sept.; Bolivar County, (10-25); A. & M. College, (8-116), 1. May, 1. Aug., m. and 1. Sept., m. Oct.; 11.

Pseudochaeta argentifrons Coquillett.

Distribution: Tupelo, 1. Sept.; Ratliff, m. Sept.; A. & M. College, e. and 1. July, 1. Aug., m. and 1. Sept., e. Nov.; 67. *Habits:* Adults are frequently abundant between early July and middle September, persisting until early November. They have been encountered in large numbers feeding

from the nectaries of cowpeas. During three of the six seasons, 1920-1925, they have, at some time during the summer, been trapped by hundreds at the upper windows of college buildings, about 40 feet from the ground. During the same intervals, very few were trapped at the lower windows in the same buildings. Both sexes were present in about equal proportions among the trapped specimens. A few other species, but by no means all that were known to occur in the immediate vicinity, contemporaneously, were trapped with *argentifrons*, but in smaller numbers. Other species were taken at these windows, which were never found on the vegetation of the vicinity. The circumstances under which these flies were captured makes it seem probable that they were migrating at a considerable elevation from the ground.

Prospherysa aemulans Van der Wulp.

Distribution: A. & M. College, m. Sept.; 1. Taken from cowpeas.

Vanderwulpia sequens Townsend.

Distribution: A. & M. College, l. July; 1. Trapped at window about 40 feet from ground.

Houghia setipennis Coquillett.

Distribution: A. & M. College, m. Sept.; 1.

Exorista larvarum (Linné)

Distribution: Woodland, l. June; A. & M. College, m. May, l. June, l. July, e. and l. Nov.; Macon, m. June (J. V. Pace); 17. *Hosts:* the salt-marsh caterpillar (*Estigme acraea* Dru.), and an Arctiid (*Apantesis oithona*) feeding on cotton.

Exorista simulans (Meigen).

Distribution: A. & M. College, l. Oct.; West Point, m. May; 2.

Wagneria sp.

Distribution: A. & M. College, m. Dec.; 3. *Hosts:* *Epsilia fungorum* G. & R.

Gonia sagax Williston.

Distribution: Starkville, l. Apr. (J. M. Falkner); 2. From the cocoon of an undetermined Arctiid

Gonia senilis Williston.

Distribution: A. & M. College, l. June, l. July, e. Aug.; 5.

Gonia texensis Reinhard.

Distribution: A. & M. College, m. Aug., e. Sept. (H. Gladney and Allen); 12. *Habits:* adults were moderately abundant in the late summer of 1924 at the flowers of *Bidens aristosa*, the nectaries of cowpeas, and hovering over tall-grass meadows.

Gaediopsis flavipes Coquillett.

Distribution: A. & M. College, l. Apr., m. July, throughout Sept.; e. Oct.; 11. *Habits:* Adults common but rarely abundant, have been observed on the foliage of mung beans and crimson clover, and several times feeding at the nectaries of cowpeas.

Spallanzania hesperidarum Williston.

Distribution: A. & M. College, m. Apr., Nov.; 2.

Cuphorocera fuscata (Van der Wulp).

Distribution: A. & M. College, e. Nov.; 1.

Copecrypta ruficauda (Van der Wulp).

Distribution: Lakeview, e. Oct. (R. W. Harned); Holly Springs, l. Sept.; Greenville, m. Sept. (F. M. Hull); Grenada, m. Sept.; Tupelo, l. Sept.; Starkville, m. Aug.; A. & M. College, m. and l. Apr., l. May, e. July (F. M. Hull), l. Aug., m. Sept., l. Nov.; Columbus, m. July (F. M. Hull); Utica, (8-139); 44. *Habits:* A common species, the adults of which frequently occur in great abundance feeding at the flowers of a number of common plants or active over dense herbaceous vegetation.

Archytas analis (Fabricius).

Distribution: Holly Springs, 1. Sept.; New Albany, 1. Sept.; Tupelo, 1. Sept.; Grenada, m. Sept.; Weilermann, 1. May; A. & M. College, 1. Mar., e. and m. Apr., throughout June and July, m. Aug., m. Oct., 1. Nov.; Leakesville, m. Aug.; Moss Point, e. Sept.; Bay Saint Louis, m. Sept.; **308**. *Feeding habits:* (6-425). *Hosts:* (6-432).

Archytas aterrima (R-Desvoidy).

Distribution: Holly Springs, (8-143); Tupelo, 1. Sept.; A. & M. College, m. July; Purvis; **8**.

Archytas hystrix (Fabricius).

Distribution: Holly Springs, (8-142); A. & M. College, 1. June (J. R. Furr), 1. Aug., e. and 1. Nov.; Charleston, 1. Aug.; **8**.

Microphthalma disjuncta (Wiedemann).

Distribution: A. & M. College, 1. Apr., e. May, e. Sept.; Utica, (8-138) (3-4); Mississippi, (9-18); **10**. *Habits:* Adults were observed on tall grass in moderate numbers early in the spring of 1921.

Spathidexia dunningi (Coquillett).

Distribution: Holly Springs, 1. Sept.; Tupelo, 1. Sept.; Longview; A. & M. College, m. Apr., e. May, 1. July, 1. Aug., m. Sept., e. and m. Oct.; Ocean Springs, e. Sept.; **27**. *Habits:* Adults, which are frequently abundant, have been swept from grass and trapped at third-story windows of college buildings and on screened porches.

Melanophora roralis (Linné).

Distribution: A. & M. College, 1. Nov. (H. W. Chalkley); **2**.

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A PRELIMINARY STUDY OF LARVAL STRUCTURE IN THE DRYOPIDÆ.

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I. INTRODUCTION.

(a) *Plan and scope of the work.*

Originally undertaken with a view to making a substantial contribution to our knowledge of the biology of this group, the present work is manifestly incomplete. Circumstances prevent further investigation in the immediate future however, and it is felt that the results which have been secured are such as to warrant publication at this time. The nature of the work may be briefly explained:

All larval material available in this family has been separated into a number of distinct types, which are described herewith in detail and are accompanied with figures showing all the important distinguishing structures. The possible identity of these types, in most cases, can be only inferred by reason of their association with adult forms already known, but since no attempt has been made to establish the identity of these forms beyond the genus, such inferred identifications answer quite satisfactorily the purposes of this paper. These various larval types are then discussed with reference to the adaptation of their form and structure to the environments in which they are found, and there is included an attempt at interpretation from a phylogenetic point of view. To make more clear the distinguishing characters, also to provide for ready detection by other workers of any types not here treated, a brief analytical table is appended.

The writer is of course aware that modern views associate the Heteroceridæ and Georyssidæ with the Psephenidæ, Dryopidæ and Elmidæ in the superfamily Dryopoidea, as set forth in Leng's Catalogue ('20). In the present paper, however, the family name Dryopidæ is used in its older sense, as inclusive of the three subfamilies—Psepheninæ, Dryopinæ and Elminæ. (Cf. Parnidæ of Blatchley's Catalogue, also of Zaitzev ('08, '10).

(b) *Sources of material; acknowledgments.*

All material used in the present study was taken within the boundaries of the United States. A major portion was collected by the writer in the vicinity of Ithaca, N. Y., but a considerable quantity of western material was furnished by Dr. J. G. Needham, to whom the writer desires to make acknowledgment for much helpful encouragement and advice. Thanks are also due to Dr. W. T. M. Forbes, to Dr. G. C. Embury and to Professor W. A. Clemens for various courtesies extended during the course of the work, likewise to Dr. Adam G. Boving, for the privilege of studying the unpublished manuscript of his paper "On the Classification of Beetles According to Larval Characters."*

II. PREVIOUS STUDIES.

Although a very large number of titles have to do with Dryopid Coleoptera from a *taxonomic* point of view, those papers dealing with the *biology* of the group are much less numerous, and are, for the most part, widely scattered. Hence the literature as a whole affords but scant assistance in the study of larval characters. The works of certain authors, however, have proven of considerable value and should be mentioned at this point.

Müller (1806) is apparently the first to take special note of the immature stages of these forms. He is followed by other European writers, notably Westwood ('39) and Erichson ('41, '48) who record various general facts concerning both structure and behavior. DeKay ('44) makes the unhappy blunder of describing the larva of *Psephenus lecontei* Lec. as a new species of Crustacean (*Fluvicola herricki*), the identity of which is finally set right by Le Conte ('49, '50), whose correspondence with T. W. Harris (published 1869) likewise furnishes certain interesting and valuable information. Dufour ('62), Perez ('63), Laboulbène ('70), Rolph ('74), Friedenreich ('81) and Beling ('83) treat largely of European forms while Hubbard ('80), Kellicott ('83), Leng ('94) and Lataste ('97) have contributed to our knowledge of various American types. Matheson's ('14) note on the life histories of *Psephenus lecontei* Lec. and *Stenelmis*

*To be published in the Proceedings of the Entomological Congress, held at Ithaca, August, 1928.

bicarinatus Lec. is an important contribution. A valuable account by Boving ('26) of the immature stages of *Psephenoides gahani* Champ. may be said to complete the list of important papers on the biology of the Dryopidæ. The writer's notes on *Psephenus* and *Macronychus*, also his "Bibliography of the Drypoidea," published during the past year, may perhaps be found useful by subsequent workers.

III. DESCRIPTIONS OF LARVAL TYPES.

The larval types here treated are nine in number. In addition, a description (in English) of the larva of the European species, *Elmis æneus* Mull. is included for sake of comparison with related American forms. For the purposes of this paper, it was deemed advisable to emphasize only those differences which may probably be regarded as of generic significance, leaving a more complete analysis until such time as the actual identity of the species in question can be known. So far as circumstantial evidence warrants, the *probable* identity of the larva is indicated in each case.

TYPE 1. *Psepheninæ* (*Psephenus*).

Form flattened, elliptical, bearing superficial resemblance to a trilobite. Larva proper concealed beneath an arched carapace, formed by extension of the pleurites of the first ten body segments. "Lateral lobes," especially in mature larvæ, closely approximated, fused on basal third, each tending to overlap slightly the lobe immediately posterior. Entire peripheral border ciliated, and capable of being closely appressed to the rocks. Lateral lobes of eleventh body segment tending to become obliterated. Caudal segment (ninth abdominal) composed of a broad, flat, rectangular dorsal sclerite, and a minute ventral one, nearly four times as broad as long. Anal opening situated between dorsal and ventral sclerites of last abdominal segment.

Head visible only in ventral view, being covered dorsally by that portion of the carapace derived from the prothorax; capable of being directed either downward or forward by means of a muscular apparatus suggesting a "ligamentum nuchæ," in position and function.

Antennæ three-segmented, elongate, the first segment about equal in length to the distance between the ocelli, the second, three-fifths the length of the first, the third minute, and composed of two small segments lying side by side, the larger of which bears distally a tiny spine. First antennal segment bearing usually six hairs along posterior margin. Ocelli in two groups of six each. Labrum broad, anterior margin straight or slightly rounded, outer corners convex, each bearing a row of rather coarse spines. Mandibles large, heavily chitinized, especially

near the tips, and bearing at about mid-point of inner margin, a brush, or tuft of bristles, evidently sensory in function. Outline of mandible usually sub-triangular, but occasionally, in last stage larvæ, elongate, and appearing as though composed of a basal and a terminal portion, the sensory brush being situated on the line of division. Maxillæ large, complex, with palpi of four segments (exclusive of the palpifer). Lacinia with papillæ-like prominences, grading off into short, thick spines. Galea more or less covered with stout hair. Stipes, first and second segment of palpus bearing respectively 1, 2, 2, stout bristles which in certain individuals appear to be branched. Labium short, broad, not heavily chitinized, and bearing a pair of three-segmented palpi. Tip of third segment, like fourth segment of maxillary palpi, beset with tiny tubercles evidently tactile in function. Basal segment of palpus bearing three branched spines. Mentum quadrangular, broad, divided by only a faint suture from the more distal portion.

Legs all similar, stout, rather thickly beset with hair, and each bearing a single strong claw with short interior spine. No tarsal segments other than the claw itself. Gills ventral, arranged in five pairs, and taking origin from the posterior margin of abdominal segments 2-6. Each gill tuft composed, on the average, of ten filaments, arranged somewhat in comb-like fashion. No anal gills present. Length of mature larva, 8.5 mm. Width, 5.75 mm.

Description drawn from several specimens of *Psephenus lecontei* Lec.

TYPE 2. *Dryopinæ* (*Helichus*).

(Plate I, Figure 7. Plate II).

The body form elliptical-ovate, flattened, similar to *Psephenus*, but differing particularly in that the lateral lobes of the carapace are not closely joined to one another. That portion of the carapace derived from the prothorax is characterized by backward-projecting posterio-lateral angles. Dorsal surface bearing many very small tubercles, scattered irregularly over the prothorax and the lateral lobes, but in the mid-dorsal region arranged in six longitudinal rows, the outer four tending to join up anteriorly in the pattern of a broken W. Lateral lobes of abdominal segment 8 developed as in the segment preceding. Junction of pleuræ with sternum not in line with base of lateral lobes, as in *Psephenus*, but at a considerable distance nearer the mid-line. Posterior abdominal segment flattened, sub-rectangular. Dorsal sclerite slightly longer than broad, ventral sclerite two-thirds as wide and nearly as long as the dorsal one. Entire margin of animal ciliate with curiously tufted hairs, ciliation tending to disappear on the anterior and posterior border of the more anterior lateral lobes.

Head large, concealed beneath the carapace, and usually directed forward; capable of partial withdrawal into a rather elaborate, surrounding collar, composed of a reflected portion of the integument of the neck. Antennæ moderately conspicuous, composed of three segments, the first stout, and barely twice as long as broad, the second somewhat

more slender and of slightly greater diameter at the middle than at either end, and the third duplicate, as in *Psephenus*, being composed of two similar members arranged side by side. Basal segment of antennæ usually bearing three, the second, one, strong spine. Labrum nearly two-thirds as long as broad; front margin regularly convex with slight anterior medial expansion; anterio-lateral angles heavily ciliate with hair. Mandibles large, heavily chitinized, conspicuous, similar to those of *Psephenus*, with stout interior sensory filament covered with distally directed setæ, and surrounded at the base with a considerable mass of sensory hairs. Elongate type of mandible most common, especially in more mature specimens, but short, sub-triangular form also occurs. Maxillæ complex, rather membranous, bearing small, four-segmented palpi, the distal segment being very minute. Hairs on stipes and basal segments of palpus noticeably branched. Galea without characteristic form, being roughly cuboidal, bearing distally about six, stout, curved spines, together with many lesser hairs, which cover a large portion of its surface. Lacinia tending to simulate a truncate sleeve, open along the free margin, and bordered distally with many, fairly stout spines. Labium membranous, somewhat elaborate in structure, fully twice as long as broad the mentum but doubtfully distinct from the palpi-bearing distal portion. Distal portion with heavily ciliate anterior margin, and with internal structure suggestive of differentiation into glossa and paraglossæ. Palpi of three segments in addition to the palpiger.

Legs similar to *Psephenus*, but characterized by the presence, on the ventral surface of the femur, of several modified spines (usually 6), each spine short, considerably thickened, and bearing many tiny processes. Claws each with a slender interior spine. Gills anal in position, arranged in three principal tufts and capable of extrusion between the ventral and dorsal sclerites of the posterior abdominal segment. Spiracles confined to eighth abdominal segment. Length of mature larva, 5.5 mm. Width, 3.5 mm.

Description drawn from several specimens supposedly *Helichus lithophilus* Germ. Most of the material at hand was collected from either Oneida or Tompkins Counties, New York.

TYPE 3. *Dryopinæ?* (Lara?).

(Plate I, Figs. 2, 6. Plates II, III).

Form elongate, sub-cylindrical and tapering caudally. Body segments very distinct, each appearing as though telescoped into the one preceding. Thoracic segments especially, with tergum overhanging laterally in form of a dorsal shield. Larva, in lateral view, noticeably convex dorsally, ventral surface correspondingly concave. Dorsal ornamentation of all segments elaborate, consisting of tubercles and papillæ arranged in an irregular pattern, similar for all segments. Posterior, and in part, lateral margins of each dorsal segment bearing a variable, complex row of backward-projecting processes (papillæ)

which are in turn adorned with fine spines. Ornamentation so arranged as to give effect of four longitudinal rows of large backwardly projecting processes, extending the length of the dorsum, but more conspicuous in the abdominal region. Two of these rows are sub-dorsal, two lateral. Posterior abdominal segment cylindrical at base and tapering distally; about as long as the two preceding segments taken together. Dorsal sclerite, viewed from above, terminating in two rather conspicuous, sharp processes. Ventral sclerite sub-quadrate, and bearing two elongate posteriorly directed processes on its inner (upper) surface, hooked at their tips and with many spines on basal portion.

Head roughly orbicular, directed forward, and adorned above with many tubercles of various size. Ocelli in two groups of five each, each group arranged in two vertical rows, three in the first, two in the second. Antennæ short but fairly conspicuous and noticeably hairy. First segment one and one-half times as long as broad, second more than half the thickness of the first, and one and one-half times as long. Third segment duplicate consisting of two sub-equal members lying side by side, one of which bears an exceedingly minute terminal spine, (not seen in all specimens). Labrum three times as broad as long, very spiny, lateral margins obliquely rounded, medial portion of anterior margin concave. Mandibles sub-quadrate, with deep concavity along inner margin. Inner "sensory brush" situated one-third the distance from base to tip. Tip bidentate. Outer surface of mandible very hairy, with long waving setæ. Maxillæ complex, rather heavily chitinated; cardo with a very conspicuous, sharp hook; lacinia and galea each bearing many short, thick sensory spines. Those borne on lacinia are much more robust than those on galea. Lacinia modified in the form of a truncate sleeve, open along the free surface. Stipes, near point of origin of the four-segmented palpi, bearing a considerable mass of flexible and elongate spines. Labium sub-rectangular, twice as long as broad and bearing three-segmented palpi. Mentum not to be clearly differentiated from palpi-bearing distal portion. Palpi, especially on second segment, conspicuously setaceous. Small, circular area at tip of palpus supplied with minute papillæ, serving apparently, a special sensory function. Entire margin of distal half of labium conspicuously hirsute, the longest spines occurring in the region of the palpi.

Legs stout and similar to those of other types, each terminating in a stout claw which bears internally a tapering spine. Spines present on all segments, longest on the tibia. On both femur and tibia, spines are sometimes very short and thick, but never of the "taste-bud" form found in *Helichus*. Coxæ not particularly modified for reception of femora. Gills caudal, arranged in three principal tufts and capable of being extruded between sclerites of last abdominal segment. Spiracles easily observed, situated laterally on first eight abdominal segments. Length of mature larva, 15.5 mm. Width, 2.25 mm. (Greatest expansion of prothorax).

Description drawn from several specimens collected from Yellowstone National Park, and from San Jacinto Mts., Calif.

By reason of its size and geographical distribution, tentatively assigned to *Lara avara* Lec. It might here be mentioned that according to Grouvelle, *Lara avara* is not a true Dryopid, but might better be considered as belonging to the Helodidæ. (Zaitaev '08).

TYPE 4 **Elminæ (Stenelmis).**

(Plate I, Fig. 8. Plate III).

Larva elongate, of the form of an attenuated hemi-cylinder, i. e., with ventral surface nearly flat, but with dorsum arched, so as to appear in cross-section semi-circular. Median dorsal line but faintly indicated; not elevated into a carina of any sort. Prothorax one and one-half times the length of the succeeding segment. Seen in dorsal view, margins of all body segments except the last appear bisymmetrically rounded, the margin of the prothorax alone being very slightly sinuate. Posterior abdominal segment sub-conical; the dorsal sclerite rather abruptly narrowed posteriorly and terminating in two sharp points. Ventral sclerite occupying posterior half of segment, of the form of a quadrangle with an equilateral triangle attached posteriorly; with two elongate, slender appendages, bearing numerous spines, and recurved at the tips. Entire dorsal surface of the larva, except the head, covered with a close sprinkling of fine tubercles, each of which tends to give rise to a minute, backwardly directed spine. These tubercles tend to be replaced by spines on posterior segments. Those spines along the posterior margin of each segment are more stout and elongate, forming a ciliate border to the segment. Larva slightly broadest in the region of the first two or three abdominal segments; diminishing slightly in size both anteriorly and posteriorly from this point.

Head large, exserted, rather conspicuous, being nearly three-fourths as broad as prothorax; with conspicuous Y-shaped epicranial suture visible dorsally. Antennæ short, composed of three segments; the first rather deeply inserted and but slightly longer than broad, the second much more slender, fully twice the length of the first and, seen laterally, more expanded at distal end than at the base; the third duplicate, being composed of two small, transparent articles arranged side by side, the one gradually tapering, the other more robust and of the same diameter throughout. No terminal spine has been demonstrated on either of these articles. Ocelli situated behind the antennæ, each group composed of apparently five units. Labrum simple, with lateral margins evenly rounded; slightly emarginate anteriorly. Anterior and lateral margins, as well as entire upper surface, beset with rather stout spines. Mandibles sub-triangular, distinctly tri-dentate, and bearing a large "taste-brush" on the inner surface at about one-third the distance from base to tip. Outer surface bearing at least two branching spines. Maxillæ small, with four-segmented palpi. Stipes, near base of palpus, bearing at least one stout branching spine. Small area on distal portion of last palpal segment provided with papillæ, evidently tactile in function. Lacinia lying close upon

galea and of the usual form, i. e., resembling a truncate sleeve, or cylinder, open along the exposed surface and adorned distally with a variable number of stout spines. Galea without characteristic form, bearing distally several stout curving spines. Labium membranous, nearly twice as long as broad, and bearing three-segmented palpi, of which the third segment is much the smallest and bears distally a small sensory area, where are located usually four tactile papillæ. Outside of, and opposite to first palpal segment may be found, on each side, a short, stubbed spine. Mentum rather clearly bounded by a suture at the base of the palpi. Distal portion of labium evenly convex and adorned with a great number of fine, tactile hairs.

Legs composed of the usual parts and adorned with a rather scanty covering of spines. Coxæ somewhat excavated anteriorly, and thus adapted for reception of femora. Distal portion of excavation cushion-like in appearance, with a mass of small closely ranged tubercles. Claw bearing on its inner surface a slender, and sometimes curving spine. Gills caudal, arranged in three principal tufts and capable of extrusion between the sclerites of the posterior abdominal segment. Spiracles situated laterally, one pair on the meso-thorax and one pair on each of the first eight abdominal segments. Length of mature larva, 6.5 mm. Greatest width (at first abdominal segment), .91 mm.

Description drawn from several specimens taken at Walnut Creek, Michigan, and assigned to *Stenelmis* since several adults of that genus were associated with them. Also the larva of *Stenelmis bicarinatus* Lec. as figured by Matheson ('14) comes closer to this type than to any other studied so far.

TYPE 5. *Elminæ* (*Stenelmis*?).

(Plate I, Fig. 9. Plate IV).

Larva elongate, of the hemi-cylindrical form described under type 4. Viewed dorsally, the thoracic segments are seen to be expanded somewhat, giving the appearance of deep notches between the segments. Prothorax about one and two-thirds times the length of the succeeding segment, somewhat narrower anteriorly and with a faintly sinuate impression parallel to, and near each lateral margin. First six body segments of approximately equal width, the last six abdominal segments becoming gradually less in size. Median dorsal line indicated by a faint elevation, conspicuous only on the last abdominal segment, where it forms a very low median carina. Posterior segment roughly conical, terminating dorsally in two very short, blunt processes (i. e., nearly truncate as compared with type 4). Ventral sclerite occupying posterior two-fifths of ventral surface of segment, of the form of a quadrangle with an equilateral triangle appended posteriorly, and bearing on its inner surface two slender, tapering, recurved appendages, rather generously provided with spines. Dorsum of larva without ornamentation save for almost uniform sprinkling of tubercles over all body segments. Most of these tubercles are in the form of exceedingly

short, blunt, spines, directed somewhat posteriorly. Those along the posterior margin of each body segment, other than the last, tend to be bidentate, giving the effect of a row of closely ranged spines bordering the segment.

Head comparatively much smaller than in type 4, usually conspicuously exserted, and with epicranial suture usually visible. Antennæ short, but fairly conspicuous, being directed forward, and composed of three segments, the first about as broad as long, the second twice the length of the first and only half as thick, the third duplicate, consisting of two, semi-transparent articles lying side by side, the length of the longer being equal to half that of the segment preceding. Basal segment bearing two or three fairly large spines. Ocelli situated behind the antennæ, each group consisting of apparently five units. Head, just below the ocelli, on either side bearing at least two very short, modified spines of the "taste-bud" type. Labrum about twice as broad as long, somewhat concave anteriorly, and with lateral angles smoothly rounded; bearing on dorsal surface and on anterior margin, many stout spines of varying length. Mandibles elongate-triangular, heavily chitinated, bidentate at the tip. Interior surface with a hemispherical concavity, of doubtful function since it collects all manner of debris. Inner "tactile brush" situated just below this concavity, and hirsute, largely, on the upper side only. External surface of mandibles bearing usually one stout spine besides a three or four branched sensory spine of curious form. Maxillæ small, compact, bearing four-segmented palpi. Cardo boat-shaped for reception of sub-galea. Stipes long and slender, bearing two, much branched spines near base of palpus. Galea without characteristic form, adorned distally with a variable number of stout, more or less curved spines. Lacinia lying close upon galea and of the form of a truncate cylinder, somewhat constricted in the middle and open along the exposed surface; bearing distally a number of stout, curving spines. Labium small, membranous, bearing three-segmented palpi of which the terminal segments possess each a number of very fine tactile setæ grouped at the very tip. Maxillary palpi have each, distally, a similar tactile structure. Labium with a pair of short, stout spines, situated, one just exterior to the basal segment of each palpus. Entire distal surface of labium beset with very minute papillæ, each bearing a minute hair.

Legs consisting of the usual number of parts, coxa somewhat modified anteriorly for reception of the femur, the shallow groove being bordered on either side by a tuberculate ridge. Floor of groove, near trochanter, covered with many fine, closely ranged tubercles, as in preceding species. Trochanter and femur each supplied with several short, thick, modified spines, of the taste-bud type. All segments more or less adorned with setæ of various size. Claw elongate and with a slender spine arising from interior surface. Gills caudal in position, arranged in three principal tufts and capable of withdrawal and extrusion between the sclerites of the posterior abdominal segment. Spiracles to the number of nine pairs, situated on the mesothorax and on each of the first eight abdominal segments. Length of mature larva, 5.3 mm. Greatest width (mesothorax), 0.8 mm.

Description drawn from several specimens most of which were also taken at Walnut Creek, Michigan. Tentatively assigned to *Stenelmis* because of the many structural features in which it is similar to Type 4.

TYPE 6. *Elminæ*.

(Plate 1, Fig. 5. Plates IV, V).

Form very elongate, almost perfectly cylindrical, characteristically arched dorsally, hence ventrally concave (as seen in lateral view). Length of all abdominal segments equal to, and in the last three or four greatly exceeding their thickness. Posterior abdominal segment typically sub-conical; dorsal sclerite, as seen from above, with serrate lateral margin, terminating posteriorly in two short, pointed, lateral processes. Posterior ventral sclerite occupying distal two-fifths of ventral surface of the segment; of the form of a rectangle with a broad isosceles triangle appended posteriorly, and bearing on the inner surface the usual pair or slender, tapering appendages, recurved at the tip. Appendages more or less covered with hair, also distal portion of sclerite (interior surface). Entire dorsum of larva sprinkled with small tubercles which tend to be directed posteriorly, not a few, especially near the mid-line giving rise each to a fine spine. Tubercles arranged in an even row across posterior margin of each body segment, (except the last); each is here prolonged posteriorly in the form of a double, tooth-like spine, thus giving the appearance of a spinose border for each segment.

Head somewhat elongate, directed forward and freely movable, variously adorned with small spines; antennæ inconspicuous, being usually very closely appressed; of three segments, but appearing somewhat as though made up of four, due to the rather deep insertion of the first into an elevated antennal fossa. First true segment very slightly longer than broad, and with a scanty adornment of fairly strong spines distally, second about one and one-third times the length of the first, but only half as thick, very slightly larger in the middle than at either end, and with a few sparse hairs, distally. Third segment merely an elongate slender, tapering spine, somewhat curved and nearly as long at the second segment; in my specimens at least with no tendency to duplication! Ocelli just posterior to antennæ, with apparently five units in each group. Labrum about twice as broad as long, heavily spined, the lateral corners rounded, the anterior margin showing but a very slight tendency to concavity. Mandibles elongate-triangular, heavily chitinized, tending to become bi-dentate at the tip. Inner surface smoothly concave, but nowhere deeply excavated. Inner "sensory brush" situated at a point about one-fourth the distance from base to tip, and hirsute on its upper surface only. Maxillæ typical, with cardo concave for reception of sub-galea, palpi four-segmented, and with lacinia truncate, and open along the exposed face. Stipes, near base of palpus bearing two very stout spines, one some distance below the other. All segments of palpus bearing at least a few slender

hairs. Terminal segment bearing at the distal extremity two or three sensory papillæ. Both lacinia and galea bearing distally several very stout and somewhat curved, sensory spines. Labium more than twice as long as broad with palpi of the usual three segments. All three segments of palpi sub-equal, the distal one bearing two or three terminal papillæ. Mentum with a single large spine on each side, just below first segment of palpus. Distal end of labium covered with many small papillæ, closely and evenly arranged; each bearing a tiny sensory hair.

Legs, as compared with those of most types, rather slender, variously adorned with spines, including, on the trochanter and femur several modified into the "taste-bud" type found on *Helichus* (Type 2) and certain others. Coxæ conspicuous by reason of peculiar scaly outer surface. Anterior coxal margin deeply grooved for reception of femur, which groove is cushion-like distally, by reason of the presence of fine tubercles, and is bordered on each side by a row of heavily chitinated teeth. Gills caudal, arranged in three principal tufts and capable of extrusion and withdrawal between the sclerites of the last abdominal segment. Spiracles situated laterally, one pair on the mesothorax and one each of the first eight abdominal segments. Length of mature larva, 6.1 mm. Greatest vertical thickness (mesothorax), .45 mm.

Description drawn from specimens collected by Dr. Needham at Dark Valley, San Jacinto Mts., Calif. It is impossible to assign them to any group smaller than subfamily with the knowledge at hand. That they belong in the Elminæ is beyond question however, by reason of the many structural similarities between this and other types of the group.

TYPE 7. *Elminæ*.

(Plate I. Fig. 1. Plate V).

Form extremely elongate, almost perfectly cylindrical throughout. Thorax nearly as long as meso- and metathorax taken together. Posterior abdominal segment typically subconical, nearly as long as the two segments preceding and squarely truncate at the tip, i. e., with no pointed, backwardly directed prolongations. Ventral sclerite occupying distal two-fifths of posterior segment, sub-ovate in outline, and bearing on the inner surface the usual pair of elongate, tapering, and recurved appendages. Spinose ornamentation of sclerite and its appendages rather delicate as compared with many types. Entire dorsum of animal sprinkled with small tubercles, each terminating more or less distinctly in a very short, backwardly-directed spine, those along the posterior margin of each segment bearing larger spines which are thus arranged in a regular transverse row across the segment.

Head sub-orbicular, with many spines and hairs on the front, also surrounding the ocellar regions, mostly directed backward. Profile view of head suggesting a rhinoceros, the impression being due to a curious, carinate elevation involving principally the clypeus; very conspicuous. Entire head directed forward and freely movable.

Antennæ very short and robust, composed each of three segments, the first about as broad as long, and profusely adorned with long hair on the upper surface of its distal border, the second, one and one-half times as long as its greatest width, somewhat tapering, and bearing distally a very few, weak hairs, the third duplicate, being composed of two sub-ovate, semi-transparent papillæ. Ocelli situated behind the antennæ; apparently with five units in each group. Labrum short, broad, with anterior margin, and especially the rounded lateral angles bearing many stout, upturned spines which give the appearance of a "mouth brush" of generous proportions. Mandibles sub-triangular, with a slight protuberance on outer surface, at about one-third the distance from base to tip. This protuberance bears a small, branching tuft of spines and is opposite in position to the inner "sensory brush," which is surrounded at its base with a collar of short bristles. Tip of mandible distinctly tri-dentate. Maxillæ elaborate but typical, with cardo boat-shaped, adapted for the reception of subgalea, with palpi four-segmented, and with lacinia in the form of a truncate sleeve largest distally and open along the exposed surface. Both lacinia and galea bearing several stout, curved spines, those borne by galea being fewer in number, but slightly more elongate. Stipes, near base of palpus bearing three large, and at least two small tufts of branching spines. All segments of palpus adorned with at least a few hairs, the distal segment bearing two small terminal papillæ. Labium membranous, broadest at distal end of mentum, which is easily distinguishable from the palpi-bearing distal portion. Mentum itself five-sixths the total length of labium, and less than twice as long as broad. Palpi very short, robust, of three segments, the terminal segment bearing distally a number of sensory papillæ. Mentum bearing on each side, at some distance from base of palpus, a single stout spine. Distal end of labium covered with small tubercles, each giving rise to a minute hair.

Legs robust, elaborately adorned with spines, both single and branched. Coxæ and femora each with a variable number of "sensory buds." Inner surface of coxa slightly excavated for reception of femur; outer surface with very heavy chitinous spurs, distally. Claw tending to be constricted near the middle at which point, on the inner surface, arises a branching spine. Gills caudal, arranged in three principal tufts, capable of extrusion and withdrawal between the sclerites of the posterior abdominal segment. Spiracles of the number of nine pairs, one pair on the mesothorax and one on each of the first eight abdominal segments, all situated laterally. Length of mature larva, 9.5 mm. Greatest vertical thickness (mesothorax), .76 mm.

Description drawn from specimens collected by Dr. Needham at Taquitz Valley, San Jacinto Mts., Calif., assigned to the *Elminæ* on the basis of structural characters. This type is interesting since it represents the extreme opposite, in almost every particular, to the form possessed by *Psephenus*.

TYPE 8. **Elminæ** (*Elmis quadrinotatus* Say).

(Plate I, Fig. 3. Plates V, VI).

Form elongate, tapering, sub-cylindrical in cross-section and with the thoracic region somewhat arched, causing the head to be directed downward rather than forward. Larva bearing dorsally three longitudinal rows of very large prominences, the median dorsal row being barely perceptible on the thoracic segments, but becoming increasingly more prominent posteriorly, the largest being that borne by the eighth abdominal segment. Dorso-lateral prominences larger on the anterior than on the posterior segments. Last abdominal segment fully twice the length of the segment preceding, roughly cylindrical at the base, tapering distally. Dorsal surface of this segment, as seen in lateral view, strongly arched and finely serrate with backward-projecting spines, tooth-like in form. Dorsal sclerite truncate posteriorly, i. e., with no sharp, backwardly-directed prolongations. Ventral sclerite ovate-elliptical, occupying nearly the entire distal half of ventral surface of the segment, and bearing on the inner surface, the usual pair of slender, tapering, somewhat recurved appendages, hairy on their basal two-fifths. Tergum of prothorax, and also of succeeding segments, to a lesser degree, expanded somewhat in a lateral direction, but not to the point of suggesting a carapace. Entire dorsal surface, including the head, beset with very small tubercles more or less uniformly distributed. Posterior margin of each body segment bordered by a row of very short, stout, closely ranged spines, arising in pairs.

Head rather elongate; freely movable. Antennæ small and inconspicuous, composed of three segments, the first scarcely longer than broad, the second more than twice the length of the first, and more slender throughout, but tending to be enlarged at the tip, the third duplicate, composed of two semi-transparent articles lying side by side, the shorter and more robust bearing distally a fine spine. Labrum sub-rectangular, with lateral angles rounded; fully twice as broad as long, the anterior margin slightly concave and sparsely covered with hair. Upper surface bearing several heavy spines. Ocelli situated just back of antennæ, with apparently five units in each group. Mandibles elongate-triangular, heavily chitinized, noticeably concave interiorly, and bearing at about one-fourth the distance from base to tip the usual sensory filament, which in this form is spined above, but not below. Tip bluntly tridentate. External surface bearing at least two curved spines. Maxillæ of usual form with four-segmented palpi and lacinia in the form of a truncate cylinder open along the free surface. Stipes near base of palpus bearing two, very conspicuous, branched spines. Distal segment of palpus with a terminal area adapted for sensory function by the presence of several delicate hairs. Lacinia and galea each with a considerable number of strong recurved, distal spines. Labium two and one-half times as long as broad, chitinized basally, but with distal portion, including palpi, almost transparent. Mentum not clearly distinct structurally from palpi-bearing portion. Palpi actually three-segmented, but appearing sometimes as four-

segmented due to the conspicuous development of the palpiger. All palpal segments somewhat beset with hair, the third bearing distally a minute sensory apparatus in the form of a few papillæ-like hairs. Entire distal surface of labium beset with many very small tubercles, each bearing a very tiny spine.

Legs of the usual number of parts, strong but perhaps more slender and elongate than those of other types. Various spined, most conspicuous feature being the two rows of strong teeth bordering the concavity extending along the anterior surface of the coxæ. Distal half of this concavity, (which serves for reception of the femur) lined with a sort of cushion, composed of closely ranged tubercles of very small size. Claw elongate, bearing on the inner surface a delicate spine. Gills caudal, arranged in three principle tufts and capable of extrusion and withdrawal between the sclerites of the posterior abdominal segment. Spiracles situated laterally, a poorly developed pair on the mesothorax, and a conspicuous pair on each of the first eight abdominal segments. Length of mature larva, 4.75 mm. Greatest vertical thickness (third abdominal segment, including median dorsal prominence), 0.62 mm.

Description drawn from several specimens taken at various localities, mostly eastern. This species was collected by J. G. Needham at Coy Glen, Ithaca, N. Y., and reared by E. A. Richmond. Several specimens were subsequently identified as *Elmis quadrinotatus* Say.

TYPE 9. *Elminæ* (*Macronychus*?).

(Plate I, Fig. 4. Plate VI).

Form fairly elongate; sub-triangular in cross-section due to a tendency of the tergum to expand somewhat laterally and also to a perceptible elevation along the median dorsal line. Posterior abdominal segment nearly as long as the three preceding, sub-conical in form, the dorsal sclerite terminating posteriorly in two short, blunt processes. Entire segment (viewed laterally) nearly straight along the basal two-thirds of the ventral surface, but dorsally, arched and minutely serrate. Ventral sclerite occupying distal third of ventral surface of the segment, sub-ovate in outline, and bearing, on the inner surface, the usual pair of elongate, tapering appendages, recurved at the tip and more or less covered with spines. Entire dorsum of larva beset with small tubercles, many of which, especially in the median-dorsal region bear each a minute, backwardly directed spine, usually double. Tubercles along the posterior margin of all body segments (except the last) arranged in a regular row and bearing each a pair of sharp, posteriorly-directed teeth.

Head very closely joined to prothorax and evidently not capable of very free movement; mouth parts directed downward. Antennæ small, of three segments, the first about as broad as long and bearing at least two rather stout spines, tending to be more or less branched, the second nearly twice the length of the first and about half as thick,

tending to possess slightly greater diameter at either end than in the middle; third segment duplicate, composed of two sub-equal, transparent articles lying side by side, one of which appears distinctly spatulate. Ocelli situated posterior to the antennæ, in two groups, one on either side of the head, each composed of five units. Labrum about twice as broad as long, heavily spined, the antero-lateral angles rounded, and with a slight, but perceptible concavity to the anterior margin. Mandibles elongate-triangular, inner margin with a deep concavity, situated just above the sensory filament; sensory filament hairy on upper side only. Outer margin of mandibles bearing one or two short branching spines. Tip of mandible bluntly bi-dentate. Maxillæ of usual form; with sub-triangular cardo adapted for reception of galea, with four segmented palpus and with lacinia in the form of a truncate cylinder open along the free surface. Galea globoid in outline. Lacinia and galea each bearing distally several stout, curving spines. Stipes near base of palpus bearing two stout, elongate spines, one situated some distance below the other. Terminal segment of palpus with at least three distal papillæ. Labium large, nearly two and one-half times as long as broad. Mentum rather easily distinguishable from distal portion, and bearing on each side just below base of palpus, a single large, curving spine. Palpus three segmented, but borne on a well developed palpiger, hence appearing sometimes as though composed of four segments. Distal segment of palpus bearing usually three small transparent papillæ, confined to a small circular distal area. Entire distal end of labium covered with many small closely ranged papillæ, each giving rise to a tiny spine.

Legs rather elongate, variously adorned with spines, most conspicuous among which are the very large, blunt, bifurcate, distally directed and heavily chitinized scale-like teeth found in the coxæ. Interior (anterior) surface of coxæ broadly grooved for reception of femora, which groove is cushion-like, distally, by reason of a massing of small tubercles within a restricted circular area. Gills caudal, in three principle tufts and capable of extrusion and withdrawal between the sclerites of the last abdominal segment. Spiracles situated laterally, one pair on the mesothorax and one on each of the first eight abdominal segments. Length of mature larva, 3.75 mm. Greatest width, (prothorax), .74 mm.

Description drawn from three specimens collected in Taquitz Valley, San Jacinto Mts., Calif., but applying almost equally well to larvæ found associated with *Macronychus glabratus* Say at Ithaca. This description, until further knowledge is available, may be assumed to apply to *Macronychus parvulus* Horn, the western representative of this genus.

To my knowledge, the foregoing types cover most of the important variations in form encountered in the United States. There is a gap, however, between the type assigned to *Helichus*

and the other, sub-cylindrical or sub-triangular types, and in order to better illustrate the gradation of form within the family, I have introduced at this point a brief description of the European larva, *Elmis aeneus* Mull.

***Elmis maugei* Bedel. var. *aenea* Mull.**

Larva elongate and noticeably flattened dorso-ventrally. Thorax much larger than the rest of the body with prothorax as long as the meso- and metathorax taken together. Prothorax emarginate anteriorly for the reception of the head. All segments of thorax rounded bisymmetrically on the sides. Abdomen forming an isosceles triangle, with the base anterior; regularly attenuated and composed of nine segments which diminish gradually in size. Margins of abdominal segments expanded into thin lateral lobes, as are those of the thorax; those arising from the abdomen, however, being not rounded, but prolonged posteriorly. Last abdominal segment truncate, conical, and slightly notched posteriorly. Ventral sclerite, or operculum, small, sub-triangular, and provided at the extremity with two appendages, recurved ventrally. Border of all body segments with exception of the last is dilated, thin, semi-transparent and adorned with a ciliate fringe, rather complex in structure. Central portion of dorsum noticeably punctured, also posterior two-thirds of lateral processes.

Head small, but entirely visible, with two pale dorsal lines united into a Y posteriorly. Antennæ short, yellowish, composed of three segments; the first broad and rather deeply inserted, the second more elongate (3 x), more slender, and bearing distally the duplicate third segment, which consists of two small articles of less than half the length of the second segment, and lying side by side. The superior of these two articles is terminated by a small spine. Ocelli, of the number of five on each side, placed behind the antennæ, and arranged in two rows, the first of three, the second of two units. Mouth bordered by a transverse labrum, feebly sinuate laterally, provided with spines which are very large at the base, having the form of a jagged scale; of these there are ten altogether. Mandibles triangular, enlarged at the base and terminating in two strong bifid teeth. On the inner surface one finds an appendage in the form of a tendril, hairy along its upper surface. Maxillæ in two lobes, each of which (galea and lacinia) bear distally a stout brush of spines. Palpi two-segmented, the second terminated by two tiny appendages. Labium trapezoidal, hairy in front, bearing two small, biarticulate palpi.

Legs short, but strong and robust, composed of a coxa, trochanter, femur, tibia, and lastly a tarsus which terminates sharply in the form of a curved claw and bears on the under surface a stiff spine. Gills caudal in position, arranged in three principle tufts and capable of extrusion between the sclerites of the posterior abdominal segment. When extruded one tuft lies directly caudad, the others lateral to the first. Spiracles distributed as follows: One pair on the anterior border

of the metathorax;* one pair on each of the first eight abdominal segments. Length of mature larva, 3.5 mm. Width, (greatest lateral expansion of thorax), 1.0 mm.

Description adapted largely from Laboulbene ('70). This species may be said to share honors with *Psephenus lecontei*, in regard to popularity in the literature.

IV. DISCUSSION.

(a) *Comparison of larval types: correlations of structures with habit:*

There exists a remarkable tendency to gradation of type from the flattened, elliptical, limpet-like *Psephenus* to the elongate, nearly cylindrical forms predominating in the Elminæ. Between extreme types one finds hardly any superficial similarity, other than in the legs, which are, throughout the group almost invariably of a common pattern, always ending in a single stout claw adapted for clinging to the sub-stratum. One can hardly say that the gradation of form includes *all* the types with which we are concerned, or that we can arrange them in a single straight forward series. Such an attempt, indeed, would be contrary to our ideas regarding the evolution of most present-day forms, which appear to represent merely the tips of branches, the stems from which they have arisen being long since extinct. Even so, if we select a certain four of the known types, namely *Psephenus*, *Helichus*, *Elmis* (European) and *Stenelmis* we shall have this gradation excellently illustrated: The closely joined lateral lobes of *Psephenus* are no longer overlapped when we encounter them in *Helichus*. They are reduced to still less useful processes in *Elmis* and are entirely lacking in *Stenelmis*. Likewise the head in both *Psephenus* and *Helichus* is concealed beneath the expansion of the prothorax. It is set rather deeply into the prothorax in *Elmis*, but is nevertheless entirely visible from the dorsal surface. In the *Stenelmis* group, however, the head is freely movable in all directions. The fact of greatest importance is that perfect homology of structure may be recognized throughout the series, the form of the first three being apparently due to

*According to Erichson ('48) the first pair of spiracles occur on the mesothorax. I am inclined to think that this is correct and that Laboulbene's interpretation is erroneous.

more or less elaborate modification of a simpler plan of structure such as is found in the fourth.

The one serious obstacle in the tracing of homologies, concerns the position of the respiratory organs. This problem, though puzzling, appears to be of fundamental significance. In *Psephenus* alone, are the gills ventral, in all the others caudal. Le Conte, more than once mentions *Psephenus* as having its chief branchial filaments in the anal region, but in this he was apparently deceived. Neither Kellicott nor I have been able to find gills in this position. The very similar larva of *Psephenoides* (native to northern India) has, however, the three-tufted anal gills characteristic of *Helichus*, *Elmis*, and related genera. This feature alone would tend to indicate that *Psephenus* is of a separate line of descent, related not so closely to either *Helichus* or *Elmis* as those two are to one another. Such an assumption is further supported to some extent by the fact that in *Psephenus* the lateral lobes, with the exception of the prothoracic expansion, seem to be composed entirely of modified pleurites, while in *Helichus* and *Elmis* the tergum plays a much more important part. It is here interesting to note that the genus *Eurypalpus* (*Psephenus*) was considered an anomalous one by Le Conte, Harris and others, before the larva was ever known. Harris criticized Le Conte freely for placing it with the Parnidae. Leading authorities now consider the genus as standing quite apart, in its capacity as type genus of the Psephenidae.

Another very interesting feature relates to the structure of the posterior abdominal segment, which is strikingly similar in most of those larvæ which have gills caudal in position. In *Helichus* alone (of American genera) are there no appendages on the inner surface of the ventral sclerite to correspond with the two slender more or less recurved processes found in all the others. Why they should here be absent, is difficult to understand. Dufour ('62) figures the not distantly related *Potamophilus* with conspicuous appendages in this position. Correlated with the lack of appendages is the fact that the caudal segment of *Helichus* closely resembles that of *Psephenus* in being broad, flattened and definitely forming part of the carapace by which the greater portion of the larva proper is covered. But the ventral sclerite in *Psephenus* is so reduced in size that appendages are virtually impossible. In all the rest, that is in those forms in which appendages are present,

the posterior segment is subcylindrical, usually tapering posteriorly, and with the ventral sclerite attached as a sort of trap-door upon the posterior portion of the ventral surface.

Bearing in mind these fundamental differences in structure we shall now attempt to show how adaptation to environment is well illustrated by the body-form of each type studied: Both *Psephenus* and *Helichus* are principally stone dwellers, the margins of their carapaces when firmly appressed to the stone being excellent aids in clinging, no matter how swift the current. They are thus able to roam at will over exposed surfaces without danger of being swept away, and by reason of the difficulty with which they may be detached, they are not an easy prey for predators. There is no doubt that *Psephenus* greatly exceeds *Helichus* in this adaptability since the more perfectly joined seams of its carapace not only make suction more complete, but seem also to exclude all silt, whereas *Helichus* can surely have but little natural protection against the dangers of muddy waters. It has the ability, it is true, to extend and to withdraw its gills, as have all the others of the family in which the gills are caudal in position, and this is no doubt protective to a degree, but the fact that *Psephenus* is the most universally distributed, at the same time most abundant in number of individuals of any genus in the group, argues well for its superior ability to meet the vicissitudes of changing environment. In the experimental work conducted in connection with this investigation it was found practically impossible to maintain alive, those types with caudal gills, due to the unavoidable amount of silt which accumulated in the hatchery troughs; but *Psephenus*, on the other hand, survived most satisfactorily, and on one occasion, when, as a result of rising water an accumulation of one-fourth inch of mud and silt covered the stones on which the larvæ were feeding, a careful washing away of the deposit revealed the entire colony alive and apparently normal. The hairy margins of their lateral lobes serve evidently as most excellent filters, to the end, that beneath the body, where the water is made to flow past the gill-tufts by the perpetual rhythmic motion of the posterior abdominal segment, there is practically no possibility of sufficient contamination to affect harmfully the respiratory apparatus. It is conceivable that they are thus able to mine beneath a layer of silt, feeding on whatever algæ may be attached to the rock, for an indefinite period of time.

The European *Elmis*, in spite of its tendency to imitate *Helichus* in the possession of lateral lobes, is obviously not able to make as good use of them as either *Psephenus* or *Helichus*. It has, however, gotten away from the cylindrical form to a very considerable extent and is assuredly better adapted for currents than are the more elongate types. It is well suited for the head-up-stream position so commonly observed in Plecopterous and Ephemerid nymphs, its backwardly-directed lateral lobes in every way suggesting adaptation for this, but we cannot conceive that it would be a successful competitor of *Psephenus* on smooth rocks, in swiftly flowing water.

All the remaining types, with certain negligible exceptions, lack any development even comparable to the carapace idea, and the situations in which they are found quite naturally reflect their structure. *Macronychus*, in particular, is a dweller of wood, rather than rock. It seeks out the crevices and makes shallow burrows for its comfort and security. Various others of the Elminæ, are, it is true, collected from stones, but they always take advantage of quiet down-stream surfaces, or of niches, or of clinging vegetation to render their position secure. All have a tendency to curvature of the body, the dorsal surface being convex, the ventral concave (as seen in lateral view), and of this they take advantage, employing the abdomen as a sort of large, seventh foot to assist in maintaining their hold.

One marked advantage, may be correlated with the lack of a carapace, and that is the possession of a freely movable head. Both *Psephenus* and *Helichus* have the head concealed. In all probability they can perceive through their carapaces various intensities of light (always reacting negatively when the stimulus is strong) but for intimate knowledge of their surroundings they must rely wholly on the tactile function of antennæ and palps. The larva of *Psephenus* in fact seems to derive its nourishment simply by scraping up everything that the surface of the rock affords, passing through the intestine that which proves indigestible. It is not conceivable that the sense of vision plays any real part in food selection. *Helichus* appears to be somewhat better equipped in this particular. Besides the fact that its carapace tends frequently to be less heavily chitinized, especially over the head region, there are, on the dorsum of the abdomen four yellowish spots, which possibly

may be more sensitive to light than other portions of the carapace. In relation to the apprehension of food, we should not fail to mention the presence of several curious bud-like processes, arranged along the under surface of the femora, in this genus. It is possible that by means of these little structures, the larva tastes, or at least explores freely with its legs, and is thus able to obtain a more intimate knowledge of its surroundings. These modified spines occur also on the legs of certain Elmid types.

It has already been mentioned that *Elmis* (European) possesses a head, which, though not capable of great freedom of movement, is at least directed forward, and is perfectly visible dorsally. It therefore represents a transition between the cylindrical types with head freely movable, and those in which it is concealed beneath the expanded prothorax.

Turning now to less conspicuous features of structure, we find that the antennæ, throughout the group, tend to be of a uniform type, consisting of three segments, the third always diminutive, and in most cases duplicate. The duplicate condition was first interpreted by Erichson ('48). This author states that the larger member, usually bearing a minute spine distally, is the true third segment. The other is construed as an appendage (modified spine) of the second antennal segment, and tends to closely resemble the true third joint. Beling ('82) in his description of the larvæ of *Pomatinus substriatus* Mull. and *Parnus auriculatus* Panz (nec. Geoffr.) mentions but a single spine as constituting the third segment in these two forms. I should have been inclined to regard his descriptions as erroneous, had I not discovered an American form the antenna of which possesses but a single member in this position. (Type 6 of this paper). The identity of this larva is at present unknown to me, but it appears to be allied with the *Elminæ* rather than the *Dryopinæ*. We may therefore regard the single or double condition of the third segment as of at least no more than generic significance. It is perhaps also worthy of note that *Psephenus*, with its concealed head, has, in proportion to other structures, the most elongate antennæ in the entire group, while type 7, the most cylindrical and elongate form studied, possesses the extreme of shortened and thickened antennal segments.

These facts all tend to show that those portions of the anatomy most freely exposed, and hence most liable to be affected by environmental conditions manifest greatly divergent modifications as we pass from one type to another. It is in the mouth parts, on the other hand, that we find most strikingly illustrated that "certain air de famille," to which Perez ('63) refers.

Concerning the labrum we need say but little save that it bears almost always a considerable number of tactile setæ. The mandibles, however, are of particular interest, for here we find the most striking similarity throughout the group. In fact the greatest differences encountered in the mandibles were between individuals of the same species, rather than between types. All have mandibles subtriangular in outline, with a conspicuous condyle on the outer angle of the basal margin. Somewhere on the inner margin, usually about one-third the distance from base to tip may be found some form of brush-like organ, either a tuft of coarse spines (*Psephenus*) or, more frequently, a finger-like filament bearing many hairs or setæ, and in miniature resembling somewhat the tail of a fox. This structure is always present, and may very probably function in the selection of food. Between this tactile organ and the tip, the mandible is always more or less excavated or grooved, the pattern of the concavity being typical for each form, as shown in the figures.

It was in *Psephenus* and *Helichus* however that the most interesting fact was brought out in connection with mandibular form, namely that two types of mandibles are possible in the same species. These have already been mentioned in the foregoing descriptions. Plate II, figure 5 shows an interesting condition, illustrative of this point, which was observed in each of two individuals of the *Helichus* series. Both these larvæ were evidently about to molt. It will be seen that the more nearly triangular mandible, belonging to the younger stage, is about to be replaced by a more elongate type, which appears almost as though made up of two parts, a broad basal, and a tapering distal portion. Both these types are to be found in *Psephenus* also, where the triangular form is predominant, even in the mature larva. Kellicott ('83) however, figures the elongate mandible as typical for *Psephenus*, and merely mentions that the mandibles of younger larvæ tend to be shorter. This

would seem to hold true for *Helichus*, much better than for *Psephenus*, since all my early dissections of the former, being made of larger individuals, disclosed only elongate mandibles, and it was not until an earlier stage was examined that the condition shown in the figure was discovered. Taking into consideration the apparent absence of mandibles *intermediate* in outline, we can scarcely hope to account for these findings by assuming that the shorter mandibles represent merely elongate types that have been worn down by continual scraping against the surface of the rocks. This point, in particular, needs further study.

The maxillæ, like the mandibles, though complex and difficult of interpretation as to constituent parts, are essentially similar throughout the group. All have four-segmented palpi, the distal member of which bears at its tip a sensory apparatus, sometimes minute, sometimes consisting of definite number of fairly conspicuous papillæ, but apparently serving a similar function in all forms. Cardo, stipes, lacinia sub-galea and galea are each represented but the basal parts tend frequently to be so fused that only lacinia and galea may be recognized with certainty. These both bear distally various spines, papillæ, and other sensory apparatus. Lacinia is often curiously modified, tending usually to take the form of a truncate sleeve, open along the free margin. This tendency is most pronounced in the Elminæ, is not at all indicated in *Psephenus*, and may prove to be of minor importance at least, as a group character.

The labium of each type, likewise, bears a fairly close resemblance to that of every other. The only conspicuous differences are those of proportion, which of course is always to be correlated, with the shape and characteristic attitude of the head. Thus we find the labium shortest and broadest in *Psephenus*, and most elongate in the type referred to *Macronychus*, but the fundamental similarity of structure cannot be ignored. In nearly all cases the labium tends to be membranous rather than heavily chitinized. The line of demarcation between the mentum and the palpi-bearing distal portion (ligula) is rarely more than indistinctly present. The distal region itself, though tending in certain types to be differentiated into glossa and para-glossæ, in most cases appears as a more or less unified structure. The palpi are always three-segmented,

though the palpiger, (as in types 8 and 9) may appear at times very much like a basal segment.

The tips of all labial palpi studied, and the distal margins of the labia themselves are always provided with sensory papillæ, or their equivalent in the form of tiny setæ or spines.

(b) *Natural grouping within the family on basis of larval characters: interpretation from an evolutionary point of view.*

We are usually safe in asserting that group characters of primary importance tend to be found in obscure places where they have had little opportunity to be affected by the influences of environment. Thus we have found, running through this family a great similarity in the structure of mouth parts, even down to minute details, while general body form, position of head and of respiratory apparatus, show great modification along more or less diverging lines. True, the food habit is similar for all, there being none but that are vegetable feeders in aquatic situations, a fact which has probably tended to preserve the fundamental character of these structures, or, at most to modify all in somewhat similar fashion. If this were not the case, we might be at considerable loss to fasten upon characters which would show clearly the family relationship of all forms studied.

When it comes to the matter of dividing the family into minor groups on the basis of larval structure, we have but a single striking character, namely, the position of the gills. *Psephenus* alone has these ventral in position. Thus it may be assumed that whatever the ancestral family type may have been, there apparently occurred, in the phylogeny of this group, a very early split, one line developing the ventral gills, while all the rest developed (or perhaps retained) a caudal respiratory apparatus. The latter type of gills being capable of withdrawal into the body, were in a measure, protected, and but little secondary modification of body form appeared in either the Dryopid or the Elmidae group. In *Psephenus*, however, the remarkable adaptation in the form of a pseudo-carapace made its appearance, serving not only to increase the ability of the animal to cling to rocks in swiftly flowing water, but also as an almost necessary protection from the silt, which must have wrought havoc with the exposed gills before they became thus protected, if, indeed, the carapace did not appear before

fixed gills replaced the spiracles. The suggestion is entirely speculative, but it is not impossible that the Psephenid stock was once equipped with caudal filaments also, such as are found in *Helichus*, and that these were not lost until conditions became favorable for more efficient use of the ventral equipment.

As for the carapace of *Psephenoides*, also the fairly pre-tentious lateral expansions of *Helichus* and their lesser homologues in the European *Elmis*, we can say only that this type of body form appears to be an adaptive structure developed independently in each group in response to external conditions. In all these forms it is useful in giving the larva somewhat of a limpet-like outline, a very desirable asset in itself, in manouvering beneath a strong current, but its adaptation as protection for the respiratory system is not found except in *Psephenus*.

Thus we see that our assumed "gradation of form" lacks any great significance except to show rather subtle tendencies of relationship, which may be partially elucidated as follows. In the Psepheninæ, all species possess the carapace-like modification in its most extreme form. In the Dryopinæ which we generally regard as lying between the Psepheninæ and the Elminæ, we find, so far as is known, the elliptical form confined to the two genera, *Psephenoides* and *Helichus*, and perhaps to only certain species of the latter. Beling ('82) has the larva of *Pomatinus substriatus* Mull., also that of *Parnus auriculatus* Panz. as cylindrical in form. But the genus *Pomatinus* is not now regarded as distinct from *Helichus* (Zaitzev, '08) and *Dryops* (*Parnus*) is certainly most intimately related to *Helichus* also. In addition, the large larva tentatively called *Lara* (type 3 of this paper) is far from resembling the *Helichus* type mentioned above, yet *Lara* has long been accepted as a close relative of both *Helichus* and *Potamophilus*. But the latter, as shown clearly by Dufour ('62) and Perez ('63) is not dissimilar from *Macronychus*, which is an Elmid genus!

Turning therefore to the Elminæ we note that the usual form is here even more cylindrical, with little or no hint of modification of the pleuræ into lobes, yet in the very genus supposed to be typical for the group, are species exhibiting a modification strongly suggesting *Helichus* (*Elmis aemeus* Mull., and *E. volkmari* Panz.). The apparent absence of similar

larvæ in America, where adults belonging to the same genus are of frequent occurrence, is assuredly of some significance in this connection. The only American *species* of which the larva is known is *Elmis quadrinotatus* Say. This larva is the sub-cylindrical, warty-backed form designated in this paper as type 8. Comparison of the descriptions will disclose little suggestive of close relationship between this larva and that of *Elmis aeneus*. Surely then, in both Dryopinæ and Elminæ, the tendency to elliptical body form cannot have more than generic significance, if indeed it has that.

Because of this nearly parallel performance of the two related subfamilies, (Dryopinæ and Elminæ), we are left without a character or combination of characters which will separate the larvæ of these two groups. This is, in a measure disappointing, but on the other hand it confirms clearly the assumption that the Psephenid stem was separate long before there existed any marked tendency for the main line to become diversified, and that there has never been a second split quite so profound as that which was responsible for the differentiation of ventral and caudal respiratory organs.*

Whatever interpretation may be placed upon the various facts brought out, it at least seems definitely assured that in *Psephenus* the greater specialization has occurred in the larva, which, by extraordinary modification of structure, has most successfully adapted itself to the environment in which it is found. Probably it is the larva alone which takes food and it is a well known fact that in the larval form only is the species able to withstand the winter. The greater portion of the life history is spent in the larval stages, and the adult is important only for the perpetuation of the species. In other words the larva has acquired, while the adult has lost, various important functions.

At the other extreme, let us consider *Macronychus*. Surely, the larva is here comparatively primitive. There are prac-

*Regarding the relationships of the Psepheninæ, Dr. Böving holds a somewhat different opinion, preferring, by reason of the ventral gills and the absence of a cloacal chamber, to derive this group from the Ptilodactylidæ. In recent correspondence Dr. Böving mentions receiving, from China, an unidentified larva, elongate-cylindrical in outline, but possessing long gills beneath the abdomen, and without a cloacal chamber. This Dr. Böving interprets as representing a connecting link between *Psephenus* and *Eurypogon* (of the Dascilloidea). The genus *Eubryanax* (hitherto listed with the Dascilloidea) should undoubtedly be transferred to the Psephenidæ as Dr. Böving suggests, since its larva is structurally very similar to that of *Psephenus*.

tically no modifications of structure to assist in clinging, other than six good legs, and it is therefore quite natural that slowly, rather than rapidly moving waters are preferred. The habit of making shallow burrows in rotten wood may be compensation for the lack of specialized body form, but at the same time the ability of the larva to move about is thereby obviously limited. In this genus it is the *adult* which is the more perfectly adapted for life on submerged surfaces. They cling tenaciously to submerged wood with their enormous claws, two to each of their six sprawling legs. These beetles live long, and are known to survive the winter. (West, '29c).

Now the general similarity between the larvæ, and also between the adults of most of the Elminæ, is strong evidence that we have here not only a single genus but indeed a whole group which is finding itself, by specialization of *adult*, rather than larval structures. These beetles, being provided with means of taking their air with them, seem to be quite unrestricted in their movements when submerged. They roam wheresoever they will, so long as the substratum is favorable for their feet. They are forsaking the aerial for the aquatic life. Dufour ('34) reports certain individuals of *Macronychus quadrituberculatus* Mull. as having but rudimentary wings, while other individuals have wings normally developed. In several dissections of *Macronychus glabratus* Say., I found only the rudimentary type present!

A further analysis of the relationships in this group must await not only added information on matters of embryology and internal anatomy, but also more detailed knowledge of life histories, that there may be established, beyond doubt, the identity of all forms under consideration. Only when this data becomes available, shall we be able to discuss satisfactorily the relationships of *genera* and *species*.

VI. ANALYTICAL KEY TO A FEW LARVAL TYPES.

(Including Six European Forms).

1. Gills ventral in position, consisting of five pairs situated on posterior margins of abdominal segments 2-6. *Psephenus* Hald.
(Type 1 of this paper, *P. lecontei* Lec.; American).
- Gills caudal in position, capable of extrusion and withdrawal between dorsal and ventral sclerites of posterior abdominal segment 2.
2. Head not visible dorsally, being covered by an extension of the prothorax. . 3.
- Head usually free, sometimes set more or less deeply into the prothorax, but always distinctly visible dorsally. 4.

3. Lobes of the carapace tightly joined except for distinct lanceolate apertures not far from the free margins. Outline broadly oval, the combined thoracic and combined abdominal segments about equal in size, forming two almost symmetrical halves.....*Psephenoides* Gahan.
(*P. gahani* Champ.; Northern India).
- Lobes of the carapace distinctly separate at all points. Outline elongate-oval, the anterior segments more expanded than the posterior. Length to breadth as 5.5-8.5.....*Helichus* Er.
(Type 2 of this paper, presumably *H. lithophilus* Germ.; American).
4. Tergum, in all body segments except the last, produced laterally in combination with pleuræ into conspicuous, more or less backwardly directed lateral lobes..... 5.
- Body form other than as above, in cross-section usually sub-cylindrical, rarely sub-triangular, but in no case with tergum produced laterally to form conspicuous lobes..... 6.
5. Form elongate-oval, gradually attenuated posteriorly. Color of first two abdominal segments not differing perceptibly from that of the others,
Lathelmis Reitt.
(*L. volckmari* Panz., as *Elmis volkmari*; European. Description after Rolph).
- Form more compact, usually smaller than the above type. Head set more deeply into prothorax, abdominal segments becoming more rapidly smaller posteriorly, lateral processes more sharply pointed and more strongly curved. Dorsum of first two abdominal segments lighter in color than the segments following.....*Elmis* Latr.
(*E. Maugei* Bedel var. *aenea* Mull as *E. aeneus*; European. Description after Rolph).
6. Third antennal segment consisting of but a single member, usually a mere tapering spine..... 7.
- Third antennal segment duplicate, consisting of two sub-equal members arranged side by side upon distal end of second segment..... 9.
7. Prothorax usually from one-fourth to one-third longer than meso- and meta-thorax taken together..... 8.
- Prothorax scarcely equal to combined length of the two succeeding segments.
(Type 6 of this paper; American).
8. Larger species, of darker coloration. Longitudinal furrows conspicuous along anterior margin of meso- and metathorax and first eight abdominal segments. Three small spines present on dorsal surface of last two segments.....*Helichus* Er.
(*H. substriatus* Mull. as *Pomatinus substriatus*; European. Description after Beling).
- Smaller species, of lighter coloration. Longitudinal furrows present as in preceding species, but much weaker. Dorsum of two posterior abdominal segments lacking the three small spines.....*Dryops* Oliv.
(*D. ernesti* Des Gozis, as *Parnus auriculatus* Ill.; European. Description after Beling).
9. Abdominal segments except the last (thoracic also, to a lesser degree) each bearing three very large more or less backwardly directed processes, one situated on the median dorsal line, the others dorso-lateral in position.....*Elmis* Latr.
(Type 8 of this paper, *E. quadrinotatus* Say; American).
- Abdominal segments sometimes ornamented with small tubercles of spiny filaments, but never bearing large processes as above..... 10.
10. Antennæ short and thick, sub-conical in form. Second segment not exceeding in length the first.
(Type 7 of this paper; American).
- Antennæ more or less elongate. Second segment always more slender than the first and usually all of twice as long..... 11.

11. Posterior abdominal segment (viewed dorsally) notched on caudal margin a distance equal to two-fifths the length of the entire segment. Mature larvæ with four distinct longitudinal dorsal carinæ. *Potamophilus* Germ. (*P. acuminatus* Fabr.; European. Description after Dufour).
Posterior abdominal segment (viewed dorsally) never notched for a distance greater than one-sixth the length of the entire segment. Not more than a single, median-dorsal, carina. 12.
12. Legs possessing a rudimentary tarsal piece at the inner juncture of the tibia and the claw, (not visible when viewed from above). *Macronychus* Mull. (*M. quadrituberculatus* Mull.; European. Description after Perez).
Legs without such rudimentary tarsal piece. 13.
13. Dorsum conspicuously ornate with backwardly directed fingers or filaments, each with a covering of small spines; larger species *Lara* Lec. (?) (Type 3 of this paper, presumed to be *L. avara* Lec.; American).
Dorsum unadorned, or at most with an even sprinkling of fine tubercles, which give a granular appearance to the surface; smaller species 14.
14. Form elongate, suggesting a hemi-cylinder, the ventral surface being somewhat flattened, the dorsal roundly arched. No perceptible elevation of the median-dorsal line into a longitudinal carina. Head usually exerted and freely movable. 15.
Form more compact, sub-triangular in cross-section, ventral surface being rather flat, as compared with the strongly arched dorsum, which bears a low, but perceptible median carina for at least part of its length. Head closely joined to thorax and evidently not capable of great freedom of movement *Macronychus* Mull. (?) (Type 9 of this paper, presumably *M. parvulus* Horn, also true for *M. glabratus* Say; American).
15. Posterior abdominal segment (viewed dorsally) with caudal margin distinctly notched, the lateral margins terminating in two sharp points, ... *Stenelmis* Duf. (Type 4 of this paper, similar to *S. bicarinatus* Lec. as figured by Matheson; American).
Posterior abdominal segment (viewed dorsally) pseudo-truncate, i. e., with caudal margin but very slightly emarginate, suggesting at most, a bluntly bilobed condition. *Stenelmis* Duf. (Type 5 of this paper, very similar structurally to type 4; American).

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EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Type 7, mature larva, lateral view. Fig. 2. Type 3, head of mature larva, dorsal view. Fig. 3. Type 8, (*Elmis quadrinotatus* Say), mature larva, lateral view. Fig. 4. Type 9, (*Macronychus?*), mature larva, dorsolateral view. Fig. 5. Type 6, mature larva, lateral view. Fig. 6. Type 3, (*Lara?*), mature larva, lateral view. Fig. 7. Type 2, (*Helichus lithophilus* Germ.), mature larva, dorsal view. Fig. 8. Type 4, (*Stenelmis?*), mature larva, dorsal view. Fig. 9. Type 5, (*Stenelmis?*), mature larva, dorsal view.

PLATE II.

Larval types 2 (*Helichus*) and 3 (*Lara?*).

Fig. 1. Type 2, antenna. Fig. 2. Type 2, leg. Fig. 3. Type 2, mandible, elongate type. Fig. 4. Type 2, labrum. Fig. 5. Type 2, mandibles of successive stages, showing marked change of form. Fig. 6. Type 2, mature larva, ventral view, (marginal ciliation omitted). Fig. 7. Type 2, labium. Fig. 8. Type 2, maxilla. Fig. 9. Type 3, leg (prothoracic). Fig. 10. Type 3, antenna.

PLATE III.

Larval types 3 (*Lara?*) and 4 (*Stenelmis?*).

Fig. 1. Type 3, maxilla. Fig. 2. Type 4, labium. Fig. 3. Type 4, maxilla. Fig. 4. Type 3, ventral sclerite of posterior abdominal segment, from within. Fig. 5. Type 4, labrum. Fig. 6. Type 4, ventral sclerite of posterior abdominal segment, from within. Fig. 7. Type 4, leg, (prothoracic). Fig. 8. Type 4, dorsal sclerite of posterior abdominal segment, from below. Fig. 9. Type 3, mandible. Fig. 10. Type 4, antenna. Fig. 11. Type 4, mandible. Fig. 12. Type 3, dorsal sclerite of posterior abdominal segment, from below. Fig. 13. Type 3, labium.

PLATE IV.

Larval types 5 (*Stenelmis?*) and 6.

Fig. 1. Type 5, maxilla. Fig. 2. Type 5, leg. Fig. 3. Type 5, labium. Fig. 4. Type 6, mandible. Fig. 5. Type 5, dorsal sclerite of posterior abdominal segment. Fig. 6. Type 5, ventral sclerite of posterior abdominal segment, from below. Fig. 7. Type 6, leg. Fig. 8. Type 5, labrum. Fig. 9. Type 5, mandible. Fig. 10. Type 5, mature larva, ventro-lateral view. Fig. 11. Type 5, antenna. Fig. 12. Type 6, labrum. Fig. 13. Type 6, antenna.

PLATE V.

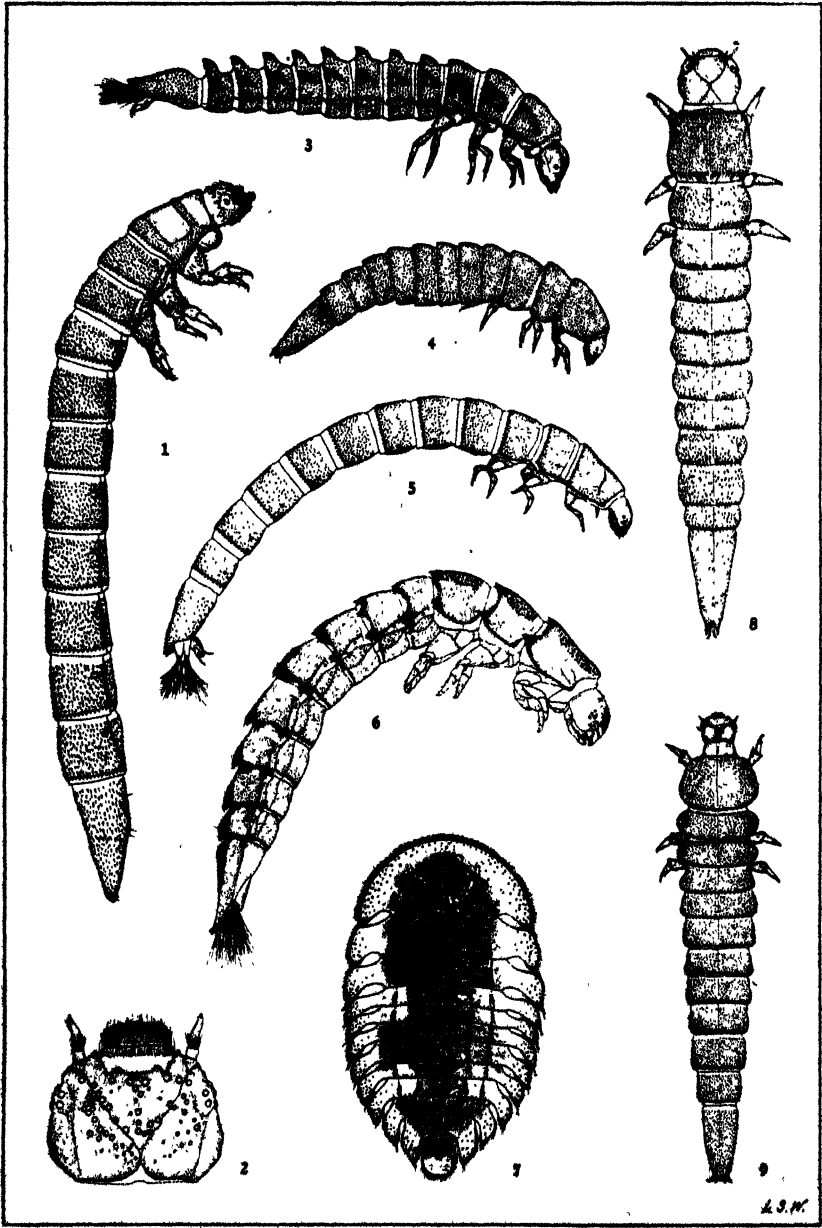
Larval types 6, 7 and 8 (*Elmis quadrinotatus* Say).

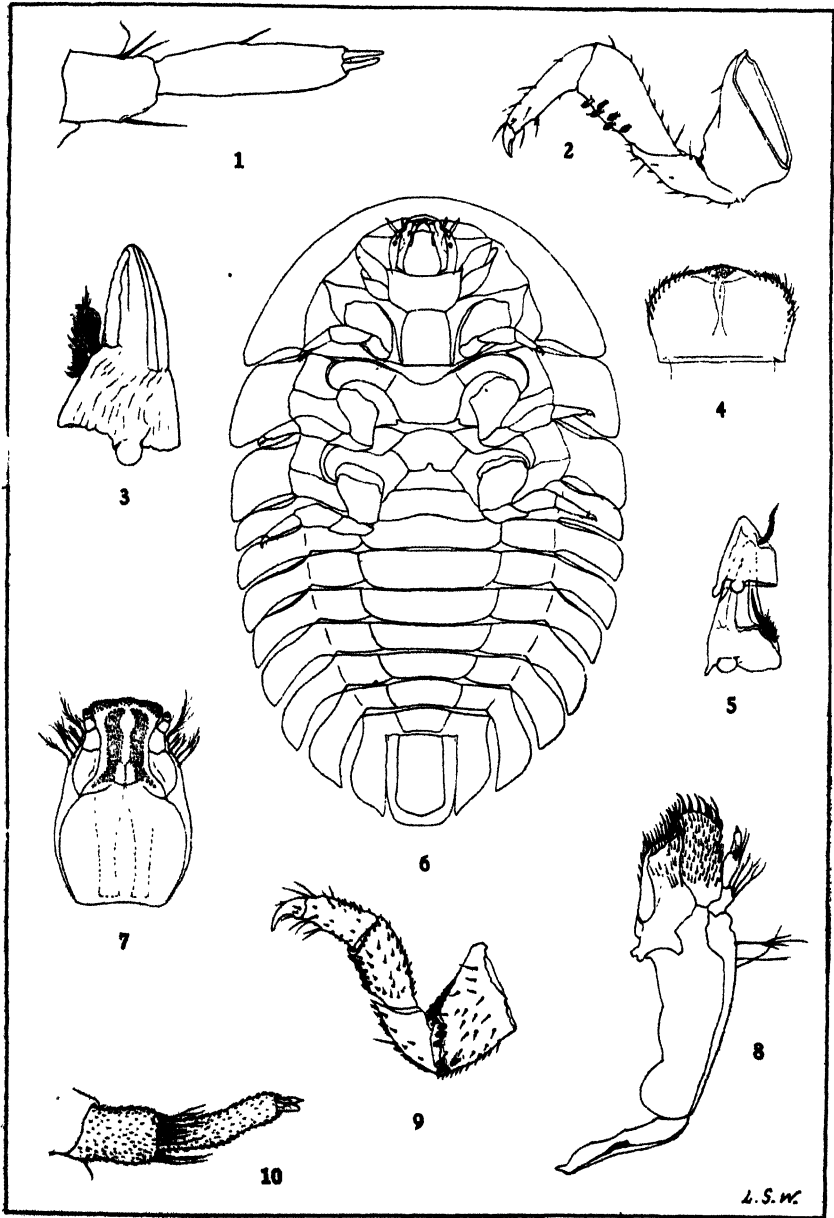
Fig. 1. Type 6, labium. Fig. 2. Type 6, ventral sclerite of posterior abdominal segment, from within. Fig. 3. Type 7, maxilla. Fig. 4. Type 7, antenna, from below. Fig. 5. Type 7, labium. Fig. 6. Type 7, leg. Fig. 7. Type 6, maxilla. Fig. 8. Type 7, ventral sclerite of posterior abdominal segment, from within. Fig. 9. Type 7, Dorsal sclerite of posterior abdominal segment, from below. Fig. 10. Type 7, mandible. Fig. 11. Type 8, antenna. Fig. 12. Type 8, leg. Fig. 13. Type 6, dorsal sclerite of posterior abdominal segment, from below.

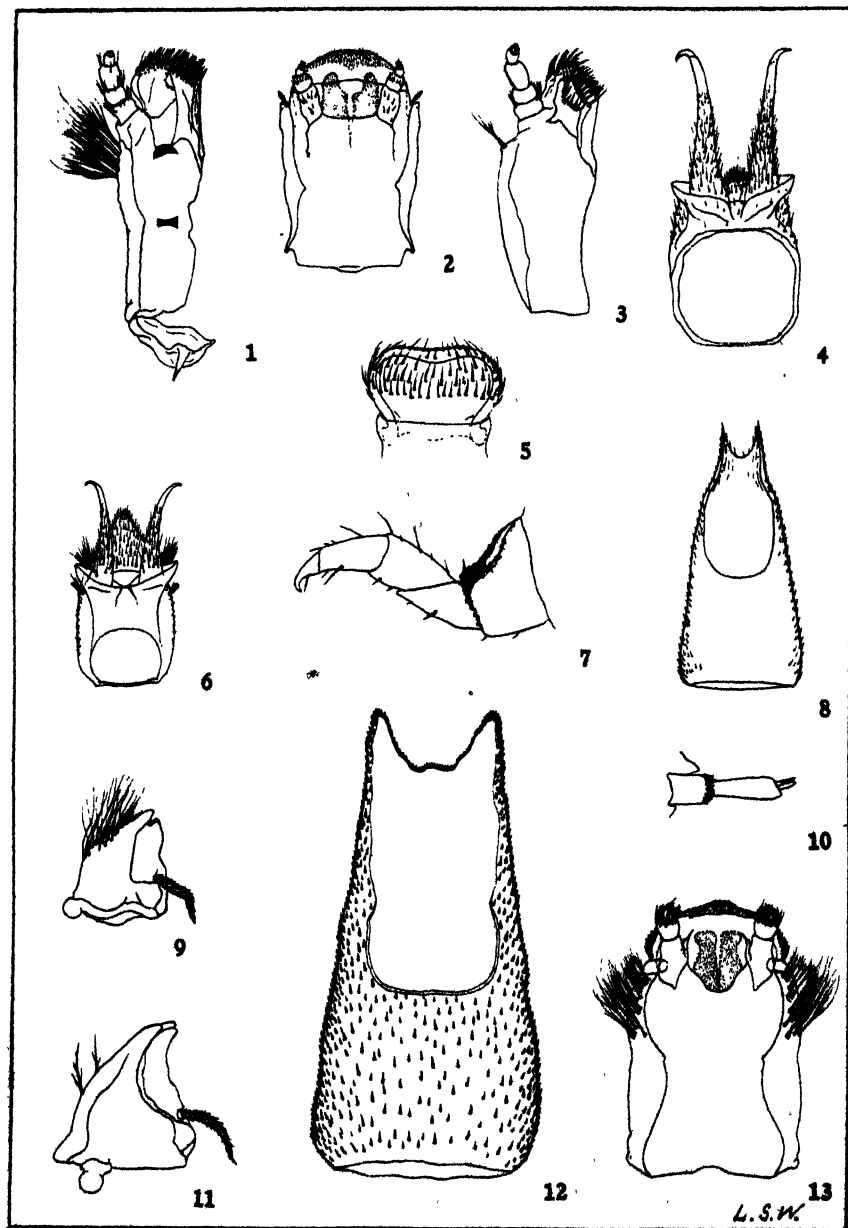
PLATE VI.

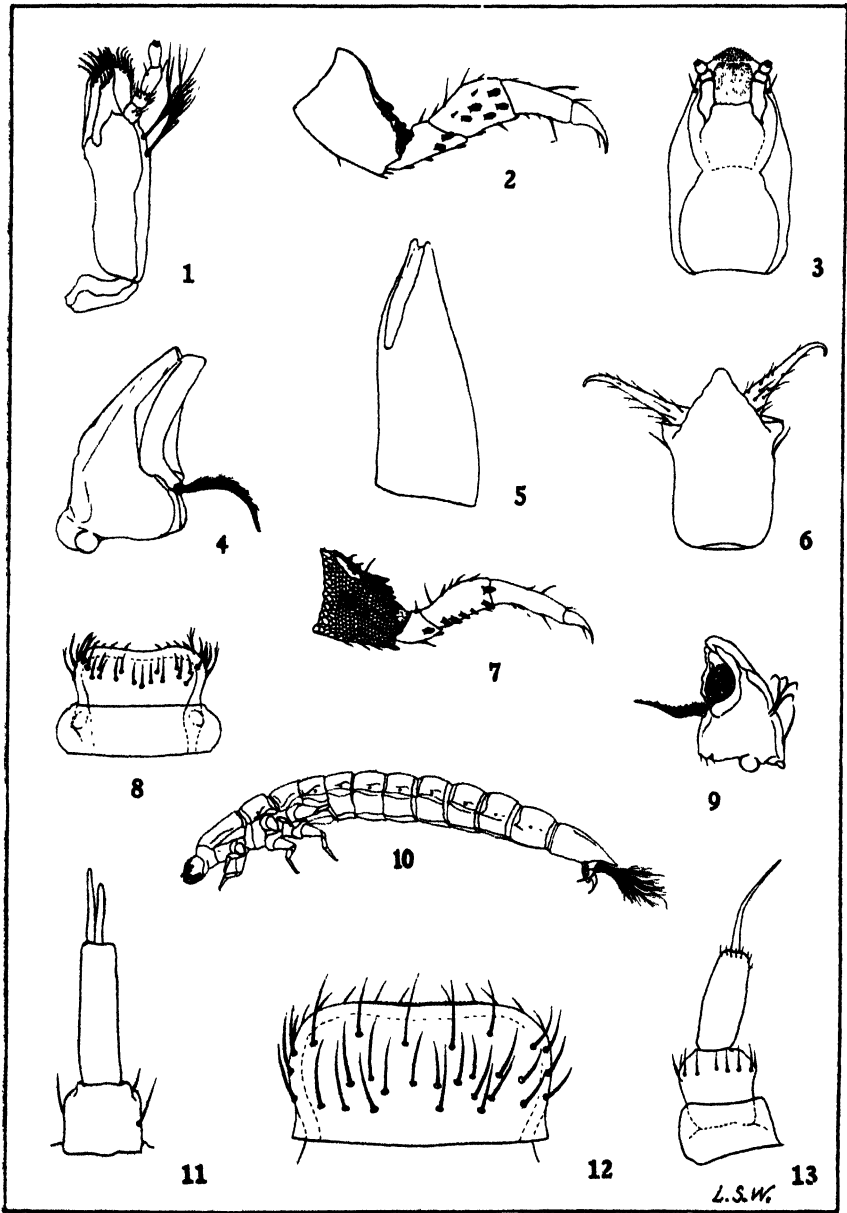
Larval types 8 (*Elmis quadrinotatus* Say) and 9 (*Macronychus?*).

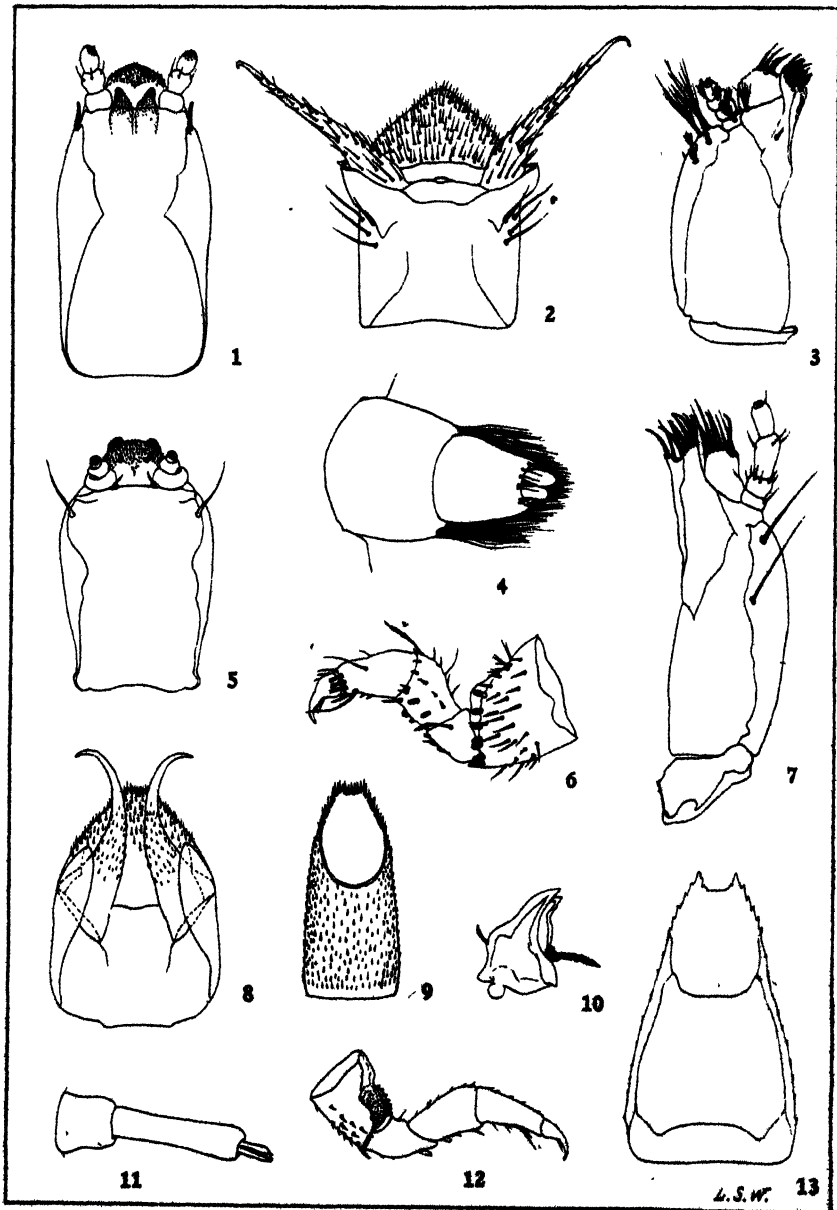
Fig. 1. Type 9, dorsal sclerite of posterior abdominal segment, lateral view. Fig. 2. Type 9, antenna. Fig. 3. Type 9, ventral sclerite of posterior abdominal segment, from within. Fig. 4. Type 8, mandible. Fig. 5. Type 9, leg. Fig. 6. Type 9, mandible. Fig. 7. Type 9, labrum. Fig. 8. Type 8, ventral sclerite of posterior abdominal segment, from within. Fig. 9. Type 8, labrum. Fig. 10. Type 8, maxilla. Fig. 11. Type 8, labium. Fig. 12. Type 9, labium. Fig. 13. Type 9, maxilla.

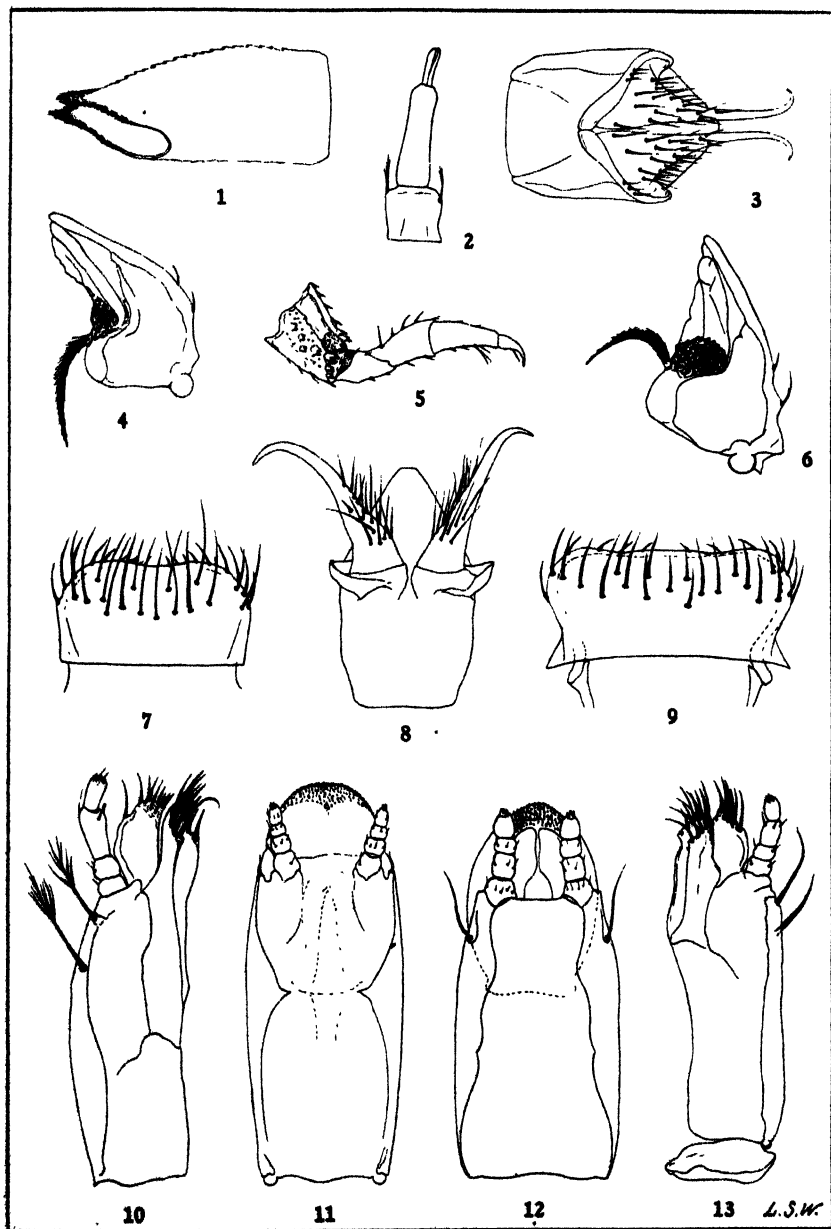












TWO NEW SPECIES OF MALLOPHAGA.

R. O. MALCOMSON,
University of Illinois.

While doing research work at the University of Illinois under the direction of Professor C. L. Metcalf two new species of Mallophaga were discovered.

These determinations have been checked by Dr. H. E. Ewing.

***Myrsidea bonariensis* n. sp.**

(Fig. 1).

Two specimens a male and a female were taken from the skin of *Molothrus bonariensis* (Cabanis), the Argentina cow-bird. This skin is in the University of Illinois Museum. The skin bears no data.

The measurements of this species are as follows:

	Male	Female
Body length.....	1.04 mm.	1.22 mm.
Body width.....	.36 mm.	.52 mm.
Head length.....	.26 mm.	.26 mm.
Head width.....	.36 mm.	.41 mm.

Description of the Female.—The head is semi-circular in front with two short hairs on the margin, one on either side of the cephalo-median point. The antennal fossæ are long and curve inward with the inner margin very dark and distinct. The antennæ are four-segmented, the distal segment is capitate but irregular in form. The antennæ lie entirely concealed from dorsal view. The ocular fringe is very distinct and is composed of stiff curved hairs. The prothorax is narrow, but the pterothorax is as wide as the head, and contains on each caudo-lateral margin a single spine. The abdomen is clothed with many short hairs and spines on the lateral margins extending as far toward the median line of the body on both dorsum and venter as the heavier chitinized parts extend. Short spines are present on segments 1 to 4, inclusive.

On the last abdominal segment of the male there are two pairs of exceedingly long hairs.

This species closely resembles *Myrsidea cyrtostigma* (Kellogg and Chapman), which was taken from several passerine birds of Hawaii. The measurements are very nearly the same. The pterothorax is much longer than that of *bonariensis*. The

short spines on the abdomen in *bonariensis* are confined from the 1st to the 4th segments inclusive, while in *cyrtostigma* the spines are located on the 2nd to the 8th segments.

Type and allotype material has been deposited in the Illinois State Natural History Survey Collection.

***Philopterus cristata* n. sp**

(Fig. 2).

Six specimens, two males and four females were taken from the skin of the blue jay, *Cyanocitta cristata cristata* (Linné).

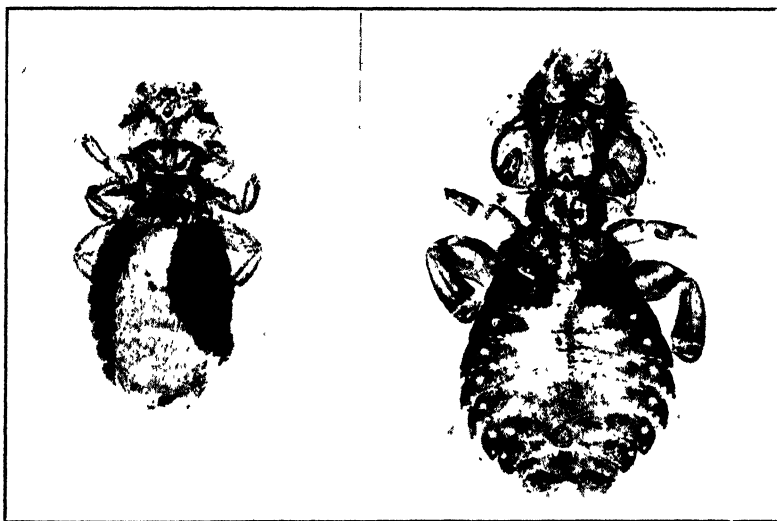


Fig. 1. *Myrsidæ bonariensis*, n. sp.

Fig. 2. *Philopterus cristata*, n. sp.

The skin from which these were taken is in the Illinois Natural History Survey Collection. Since taking these specimens I have found the blue jay to be very heavily infested with this particular species of louse.

Description of Female.—The body length is 1.69 mm. and body width is .79 mm. The head length and width is the same, .57 mm. The forehead is broad. The clypeus has two hairs in front, one on each side. The signature is very prominent, extending to a point caudad of the mandibles. The ocular emargination is shallow and broadly curved. The first segment of the antennæ is exceedingly large, the second segment is the longest, being as long as two of the three

distal segments. The trabeculae are large, extending to the end of the first antennal segment. They curve caudad and in toward the body. The mandibles are large. The eyes are prominent and contain a single hair. Just below the eyes and on the lateral margin is a second long hair. The temporal margin on each side bears three long hairs. The prothorax is comparatively small, with a long hair in the caudo-lateral angle on each side. The first pair of legs is short with exceedingly large femora. The pterothorax is almost as large as the head. There are four long hairs in the caudo-lateral angles of the pterothorax. Twenty-four long pustulated hairs are visible from the dorsal view along the caudal margin of the pterothorax. The lateral blotches on the abdomen resemble those of *Philopterus quiscali* (Osborn). The eighth abdominal blotch extends unbroken from one side of the body to the other. The ninth abdominal segment is divided into two triangular chitinous areas with a constriction curving cephalad. The abdomen is very generally covered with long hairs.

This species is very similar to *Philopterus thryptocephalus* (Kellogg and Paine), which was taken from *Gracilus gracilus* an Old World bird, which has been classed with the jays.

It differs from *thryptocephalus* in the shape of the head. The head of *cristata* is just as long as broad, while the head of *thryptocephalus* is broader than it is long. In *thryptocephalus* the cephalic angles of the clypeus are rounding and the cephalic margin of the clypeus is curved, while in *cristata* the angles are more acute and the cephalic margin of the clypeus forms a straight line.

Type and allotype material has been deposited in the Illinois State Natural History Survey Collection.

BOOK NOTICE.

LABORATORY AND FIELD ECOLOGY, by Victor E. Shelford. Williams and Wilkins. pp 608, text figs. 219.

In this case the reviewer is deviating from the inflexible (?) rule of the editorial office that no books are reviewed unless free copies are sent the Editor. This volume is of such outstanding value to all experimental entomologists, which term includes all men in the economic game, that it must be called to the attention of all members of the Society. It is a compendium of research previously done and particularly of apparatus of use in experimental work. We prophesy that for some years to come it will be the Bible in every experimental laboratory. It is a method book comparing with Lee's *Vade Mecum* in the histological laboratory. It has a bibliography of 1,012 titles constantly referred to by number in the text, which makes it extremely useful in opening up the whole field of literature. The price seems large, but it is worth every cent of it.

C. H. K.

A STUDY OF RESPIRATION AND RESPIRATORY ORGANS OF THE RAT-TAILED MAGGOT, ERISTALIS ARBUSTORUM L.

(Diptera: Syrphidæ)

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INTRODUCTION.

It is, of course, well known that among insects there are two general types of respiratory apparatus: the open type in which from one to ten pairs of spiracles function, and the closed type in which there are no functional spiracles and in which the insect obtains air by diffusion through a membrane. Of the two the latter type is much more rare. The majority of larvæ of aquatic insects have either tracheal gills or blood gills present as means of obtaining air from the water in which they live. According to Imms (5) these gills may be the only means of respiration in a typically closed system, but often they occur in connection with open spiracles in certain insects (larval Culicidæ for example).

The *Eristalis* larvæ, breathing normally through one pair of spiracles at the end of the long, tail-like breathing tube, would be classed with those insects having the open system. At certain times these larvæ, commonly known as Rat-tailed Maggots from Reaumur's "vers a queue de rat" extrude from the anal aperture several slender, finger-like appendages which usually wave about with a rhythmical motion. These are exceedingly well supplied with tracheæ which arise from the main respiratory system.

The resemblance of these finger-like processes to tracheal gills and their location in connection with the rectum have earned for these structures the name "rectal gills" from some authors. Buckton (2) however has suggested that they represent rudiments of the curious rectal glands of the adult fly. The writer believes no investigator has ever submitted any

*Contribution from the Department of Zoology and Entomology, Iowa State College.

positive evidence to show these structures to be part of the respiratory system.

The present problem therefore was attacked with a dual objective: first, by means of close observation and experimentation to determine the nature of the respiratory organs and the means of respiration in this insect; and second, to discover, if possible, a connection of the above-mentioned finger-like processes with the respiratory function and thus demonstrate beyond a doubt that larvæ of *Eristalis* do have both open and closed types of respiratory apparatus.

The larvæ for this study were found living in great numbers in the foul ooze and decaying animal matter which flowed down a small stream from an abattoir and fertilizer plant at Boone, Iowa.

The writer wishes to express his gratitude to Dr. B. B. Fulton and Dr. W. H. Wellhouse for suggesting the problem and especially to the latter, under whose direction the work was done, for kindly aid and helpful criticism.

HISTORICAL.

According to Vinal (19) the foundation work which furnished the basis for all modern work on the subject of insect respiration was the elaborately illustrated monograph of Straus-Durckheim (1828) on the cockchafer, *Melolontha vulgaris* L.

As early as 1738 Reaumur (14) seems to have observed that *Eristalis* larvæ possessed two large tracheal trunks which got their air supply through a pair of spiracles at the end of the long, tail-like appendage. He had noted also the anterior stigmatic horns as parts of the respiratory system and likewise had seen the retractile, finger-like processes protruding at times from the anal aperture.

Miall (12) in 1895 observed the plumose setæ surrounding the tip of the breathing tube and in addition mentioned the three sections into which the breathing tube is divided. He undoubtedly erred in his statement that the large tracheal trunks connect with non-functional spiracles at the anterior end of the body.

Buckton (2) observed the finger-like projections from the rectal region of *Eristalis tenax*, but appeared not to have been positive that the vessels within these had a connection with the tracheal system. He concurred with Miall in the belief

that the main tracheal trunks do not open anteriorly in the larvæ.

The work of Wahl (1900) gives a most detailed and complete account of the tracheal system of *Eristalis tenax*. His descriptions and drawings of that species indicate a close similarity in anatomy of respiratory system with that of *Eristalis arbustorum*, the species which furnishes the subject for the present paper. This investigator concluded that the posterior spiracles are the only openings to the tracheal system and that therefore this insect has the metapneustic type of respiratory system. The writer believes this to be an error because tests performed on larvæ of *Eristalis arbustorum*, demonstrated conclusively that there is a pair of functional spiracles at each end of the body. It seems highly improbable that species so similar in other respects should differ in this respect.

DESCRIPTION OF THE INSECT.

The Larva.

Like all other larvæ of this genus and of some other genera whose larvæ are fitted for aquatic existence, the larva of *Eristalis arbustorum* L. is peculiar in having the long, retractile, tail-like breathing tube at the end of which the posterior spiracles open. The breathing tube is in three sections, each of the two distal sections of which is capable of telescoping within the segment proximal to it (Plate I, Fig. 1). The distal one is necessarily much the smallest in diameter, is considerably sclerotized and stiffened, and has at its extremity eight minute, feather-like setæ (Plate I, Fig. 1, 2, and 3). Apparently a waxy or oily secretion on these setæ keeps the tip of the breathing tube from being easily wet at any time and keeps water from entering the spiracles. At the anterior end of the larva are two small, horn-like projections through each of which opens the forward end of one of the two main tracheal trunks (Plate I, Fig. 4 and 5).

The body proper of the grown larva is approximately thirteen millimeters long and three and one-half millimeters wide. The breathing tube varies in length from fourteen millimeters, while in a normal, telescoped position, to fifty or more millimeters, when fully extended. In general shape the body is sub-cylindrical and bluntly rounded at the anterior

end. See Plate I, Fig. 1 and 5. There are six pairs of short, blunt prolegs each bearing several sclerotized claws. In addition to the six pairs of prolegs there is another pair of similar structures far forward on the body immediately below the mouth. It is believed that the members of this pair do not represent true locomotor structures, but rather are modifications of the folds below the oral opening and are used more in feeding than in locomotion.

THE TRACHEAL SYSTEM OF THE LARVA.

With the exception of the more primitive insects it could be said that normally an insect having the open type of respiratory system has at least two main tracheal trunks which extend nearly from end to end in the body cavity and open to the exterior by a variable number of paired spiracles along the sides of the body. This view, of course, does not recognize origins of parts.

The larva of *Eristalis arbustorum*, essentially a highly specialized animal, has apparently undergone some decided modifications in respiratory apparatus to fit its mode of existence. Since this insect is an aquatic or semi-aquatic creature, it has not been able to make use of the ordinary spiracles of the typical holopneustic insect, but has been confronted with the necessity of obtaining a supply of air while buried from one-half inch to two or more inches below the surface of mud or water.

The most obvious elements of the tracheal system of *Eristalis arbustorum* consist of two longitudinal tracheal trunks with two main tracheal connections between them. These two connections are the *anterior commissure* and the *posterior commissure* as seen on Plate II, (*Atc* and *Ptc*). At the anterior end of each longitudinal trunk is an ear-like *stigmatic horn* (Plate I, Fig. 4a and Plate II). These horns serve as the forward openings of the tracheal system; that is, as anterior spiracles. At the posterior end of each of the longitudinal trunks, which in this case is at the distal end of the long, tail-like breathing tube, there is also a spiracle with one or more openings (Plate I, Fig. 1, 2, and 3).

Description of Tracheæ.

Each longitudinal tracheal trunk has a diameter of about two-thirds of a millimeter (665 microns) at its greatest diameter as viewed from the dorsal or ventral side (Plate II). A lateral view makes it seem considerably smaller since the enlarged portion normally is somewhat flattened dorso-ventrally. Beginning at the base of the stigmatic horn each trachea is nearly round and has a diameter of about one-sixth of a millimeter and maintains this diameter posteriorly until it gradually enlarges to the full diameter of the longitudinal trunk. Relative sizes of the remaining parts of the tracheal system may be seen by referring to the various plates.

Plates II and IV were drawn from specimens somewhat distended in order to more clearly show the various elements of the tracheal system. Fig. 5, Plate I is included to show the normal positions of the main parts of the tracheal system.

No attempt has been made to follow the finer ramifications of the tracheæ which extend to the body-wall to determine whether they supply air to muscles or hypodermal cells.

Terminology of Parts.

Choice of a satisfactory scheme to follow in the terminology of parts of the respiratory system has been a considerable problem with the writer. It was originally planned to follow the terminology adopted by Wahl (20) but this was found to be too cumbersome. It was suggested by Dr. C. H. Kennedy that an attempt be made to homologize the parts of the tracheal system of this insect after the scheme set forth by Lehmann (10), but for various reasons this did not seem feasible except in small part. The scheme finally chosen (with some variations) is that developed by Kennedy (6) and which is based on a study of naiads of the Zygoptera.

Kennedy's conception of the homologization of parts of the tracheal systems of insects is somewhat as follows: the principal elements of tracheal systems as we find them in most insects may be considered as modifications of hypothetical primitive units, a pair of which occurred in each segment of the hypothetical primitive insect. Each one of these units consisted of the following major parts (1) a spiracle, (2) a spiracular pit, (3) a spiracular trunk, (4) an anterior dorsal

connective, (5) a posterior dorsal connective, (6) an anterior spiracular connective, (7) a leg trachea, and (8) a ganglionic trachea. In addition to these there are also several minor tracheal connections. According to this scheme of homologization, all tracheal trunks and parts which extend through more than one segment of the insect body are to be considered as being made up of parts of the hypothetical primitive units joined together in series. This conception (as far as possible) including the nomenclature adopted by Kennedy is followed in this paper. A sketch to show the parts of this hypothetical primitive unit has been included. See Plate I, Fig. 10.

Homologies of Tracheæ.

Dorsal Tracheæ.—Since the larva of *Eristalis arbustorum* does not have functional spiracles except at the ends of the body, there is considerable variation from the hypothetical type of tracheal apparatus. In addition to the two pairs of visible spiracles, the location of eight more pairs of atrophied spiracles can be determined with ease. Plate IV, *k* indicates one of these atrophied spiracles with its non-functional spiracular pit.

The anterior dorsal connective and posterior dorsal connective of each spiracle-bearing segment combine to make up the large *longitudinal tracheal trunks* which are clearly represented on Plates II, III, or IV. The tips of the anterior dorsal connectives and posterior dorsal connectives, which Kennedy found remained distinct in the zygopterous naiads, have apparently coalesced in pairs in this instance (Plate IV, 1-8). The writer therefore believes that in *Eristalis arbustorum* these should be called merely *dorsal connectives*. It may be noted however that in all but the first two pairs of these (Plate II, 1 and 2) one part proceeds somewhat anteriorly to the body-wall while another part proceeds posteriorly (Plate II, 3-8). It should be noted also that all save the first two pairs of tips provide minor commissures (Plate II, *h*) between the two main longitudinal tracheal trunks. The additional function of supplying air to the dorsal portion of the fat-body* is likewise performed by all except the anterior two pairs of these tips.

*The dorsal portion of the fat-body lies close beside the heart. It was suspected that this organ was supplied with tracheæ from the same tracheal branches as the fat-body, but no connections could be found in any of the larvæ dissected.

Only the bases of these fat-body tracheæ are indicated (Plate II, *e*). These bases are also indicated on Plate IV.

Ventral Tracheæ.—The *spiracular pits* which likely should be considered to serve as points of origin for all tracheal branches in the insect tracheal system are atrophied in the present case as has been noted. This seems to have caused the *spiracular trunk* (Plate I, Fig. 10, *spt* and Plate IV, *C*) to take on this function. In addition to giving rise to the dorsal connectives already mentioned, it serves as a point of origin for the *anterior spiracular connective* (Plate IV, *j*) which proceeds cephalad in each segment to join with the *leg trachea* (Plate IV, *p*) to form a section of the *lateral trunk*.

The *sternal trachea* (Plate IV, *n*) in each segment does not arise from the ganglionic trachea (*o*) as found by Kennedy in the Zygoptera. Rather, it has shifted down the leg trachea where it has an independent point of origin. The *ganglionic trachea* (*o*) does not arise from the spiracular pit, but has also migrated posteriorly down the leg trachea before it branches off. This interpretation reverses the serial arrangement of these two trachea in each segment as compared with their respective positions in the hypothetical segment. It should be explained at this point that the ganglia in *Eristalis arbustorum* do not retain their segmental positions, but are all coalesced far forward almost beneath the brain. See Plate III, *Soe*.

The arrangement of ganglionic and sternal tracheæ just described is easily seen in connection with all the spiracular trunks with the exception of the most anterior one. The exception in this case is that an accessory ganglionic trachea is present (Plate I, Fig. 6, *o'*). The anterior and posterior latero-tergal tracheæ do not have independent points of origin on the anterior spiracular connective and leg trachea respectively as determined by Kennedy. Instead, the writer believes these to have both migrated back onto the spiracular trunk where they have their bases in common. This compound base divides into the *anterior latero-tergal trachea* and *posterior latero-tergal trachea* (Plate IV, *s* and *m*) as it approaches the body-wall. See also Plate II, *s* and *m*.

Visceral tracheæ.—Tracheation of the internal organs of this insect is elaborately provided for. Kennedy found tracheation of the internal organs to be largely fortuitous in the Zygoptera. Such is by no means the case with *Eristalis arbustorum*.

The term "*visceral tracheæ*" as used by Lehmann (10) seems to the writer to be the best available term for use here. Plate III shows the number and location of tracheæ from the right, main, longitudinal trunk to the various internal organs. Each spiracle-bearing segment has at least one main trachea (*B*) extending to some part of the alimentary system. Each spiracle-bearing segment with the exception of *I* and *X* has also a smaller tracheal connection (*A*) to supply air to the fat-body and Malpighian tubes.

For want of better names these visceral tracheal branches will be known here as *visceral trachea A* and *visceral trachea B* in each spiracle-bearing segment. It should be noted that segment *I* (Plate III) has no visceral trachea *A*. Attention is here called also to the *accessory visceral trachea* (Plate III, *Ba*) which plentifully supplies the pharynx with air. A branch of this trachea extends far caudad to supply tracheæ to the ganglionic mass (Soe) and to form a cross-connection with its mate of the opposite side of the body.

THE RETRACTILE PROCESSES.

Whether or not the retractile processes (Plate I, Fig. 1 and 7) function as part of the respiratory system remains a question with the writer. This point will be discussed further elsewhere.

The peculiar form of these structures may be observed on Plate I, Fig. 7 where they are illustrated in an extended position outside the body of the larva. It must be remembered that the larva can, at will, withdraw these structures by turning each part inside out and withdrawing the entire group of parts through the anal opening.

Two large tracheal branches, the homologies of which are not clear, arise from a point on the longitudinal trunk (Plate III, *X*) and extend into the basal part of the retractile processes (Plate I, Fig. 7, *ba*). These large tracheæ branch many times, sending tracheal connections into the smaller apical pieces (*ti*). No anastomosing of tracheæ could be observed in any part of the retractile processes.

TECHNIQUE OF DISSECTION.

In observing the general anatomy of the tracheal system, dissections were made in a 5 per cent chloral hydrate solution after the larvæ had been killed in this solution or in hot water. Insect pins of "minuten" size were used to hold the dissected specimen in a small depression made in a wax pan. Good success was also experienced with larvæ killed in alcohol and later injected with pure glycerine. Dissections were then made in glycerine. In nearly all cases a Spencer binocular microscope with 10x or 17x oculars and 25 mm. or 32 mm. objectives was used.

For getting details of the finer ramifications of the tracheæ as shown in Plate II or Plate III, a modification of a method used by Wahl (20) was found quite satisfactory. This procedure as carried out consisted of taking the larvæ previously injected with glycerine and re-injecting them with a mixture of two parts glycerine and one part Beale's carmine solution. After from ten to twenty-four hours the larvæ could be dissected. All parts of the tracheal system were usually pink in color and comparatively easy to see. This stain colored the muscle tissue red which helped to distinguish strands of this tissue from tracheæ. For the finer work it was found best to place the dissected specimen on a microscope slide under the highest power of the binocular microscope. A microscope light was then placed beneath the specimen in order to get light directly through it from below.

RESULTS OF VARIOUS TESTS.

Resistance to Lack of Oxygen.

Observations of larvæ in their natural habitat indicated that they were apparently able to live in a situation where oxygen was none too abundant. In order to test larvæ of *Eristalis arbustorum* in comparison with common aerial insects, an ordinary laboratory suction pump and bell jar fitted with mercury pressure tube were procured in order to create as nearly a perfect vacuum as possible. Within the bell jar were placed living specimens of the following insects: cockroaches (genus undetermined), wireworm beetles (*Melanotus communis*), house flies (*Musca domestica*), codling moth larvæ

(*Cydia pomonella*), and larvæ of *Eristalis arbustorum*. Each species was placed in a cotton-stoppered, glass vial, the *Eristalis* larvæ having also water in their vial. By pumping, the pressure was reduced to a point varying from zero to one-half centimeter of mercury. This partial vacuum was kept constant until the last insect ceased activity. Below are listed the species of insects in their order of resistance from the standpoint of time. The time listed after each species indicates the period of time which elapsed from the beginning of the experiment until activity of the insect ceased. Tissues and organs of the insects were not examined for any possible physical effects due to the reduced pressure.

Cockroaches	1½ minute
Melanotus communis	1 minute
Musca domestica	3 minutes
Cydia pomonella	5 minutes
Eristalis arbustorum	20 minutes

The comparatively high resistance to lack of oxygen on the part of the *Eristalis* larvæ may be actual, or it may be due to the fact that the oxygen contained in the water in which the larvæ were allowed to remain furnished a slight supply of oxygen to these larvæ during the first part of the test. Much bubbling of the water was observed as soon as the pressure was reduced. This bubbling increased in violence directly as the pressure was reduced until finally the water became very cool. Reduction of rate of metabolism due to the lower temperature may have caused the greater resistance of these larvæ.

Resistance to Excess Carbon Dioxide and Oxygen.

In an effort to determine the effects of excesses of such gases as carbon dioxide and oxygen on the respiratory organs and on the respiratory process, a series of tests was run.

Oxygen gas was prepared by heating manganese dioxide and potassium chlorate and catching the resulting oxygen gas by displacement of water in a bottle.

Carbon dioxide was prepared in the ordinary way by treating calcium carbonate with dilute hydrochloric acid.

In the comparative tests the *Eristalis* larvæ were of necessity left in a small quantity of water and the bottle of gas inverted over them. Only two species of insects were available with which to compare the *Eristalis* larvæ. These were a small

species of ground beetle (*Agonoderus pallipes*) and larvæ of one of the *Datana* moths (*Datana* sp.).

A summary of three tests is given in Table I below:

TABLE I.
RESISTANCE TO OXYGEN AND CARBON DIOXIDE.

SPECIES	OXYGEN	CARBON DIOXIDE
<i>Agonoderus pallipes</i>	Excessive activity, scraping antennæ, raising elytra, etc. Not killed.	Stiffness and dragging of legs, followed by total inactivity in five minutes.
<i>Datana</i> sp.	No unusual activity or ill effect noted.	Immediate vomiting of yellow juice. No activity except quivering, at end of one minute. Death after six hours.
<i>Eristalis arbustorum</i>	Usual activity, no change after eighteen hours. No efforts to obtain air.	Remained near surface of water. Repeated efforts to shoot air tubes to surface for air. Sluggish after one-half hour. Slight activity at end of three hours. Apparently dead at end of four hours. An apparent derangement of internal organs noted.

Inspection of results listed in Table I shows that the effects of carbon dioxide were much slower to appear in *Eristalis arbustorum* than in the other insects tested. The reason for this is hard to ascertain unless it is due to the large reserve supply of air present in the large tracheal trunks. The apparent derangement of internal organs was not investigated further because it appeared to have no direct bearing on the problem.

Method and Rate of Respiration.

The fact that insects obtain a sufficient supply of air through their spiracles has been more or less taken for granted without much question as to what makes the air enter the tracheæ or what causes the left-over gases to pass out. Probably the work of Lee (7) on respiration in Orthoptera has been one of the most serious attempts at an explanation of the mechanics of the respiratory process in insects. Lee states that Acrididæ have both inspiratory and expiratory spiracles present.

On several occasions a living larva of *Eristalis arbustorum* was placed in the cell of a micro cell-slide with the cell filled with water, but with a cover glass in place. This arrangement put the larva in a virtual water prison. After a few minutes in this predicament, there were always considerable nervous squirmings of the larva and numerous attempts to get the tip of the breathing tube into contact with the atmosphere. If the cover glass was moved slightly to one side so as to expose a small area of water to the air, the tip of the breathing tube soon came in contact with this area and breathing was resumed. In every case, at this point, there was an almost immediate cessation of activity of the body as a whole, but a distinct internal respiratory activity was begun. The large tracheal trunks commenced a definite and more or less periodical activity. The large spiral taenidia of the tracheal trunks (Plate I, Fig. 8) suddenly flattened in a manner likened to the flattening of the spirals in a coil spring.* Plate I, Fig. 9 will illustrate better what happened. It can easily be seen that this alone would tend to force the contained air or other gases from the main tracheal system either to the outside or into the tracheal branches. However, in addition to this movement, there was also a shortening of these main trunks coincident with the flattening. Obviously this also would tend to empty the contents, and we might consider these two movements to constitute one exhalation or expiration. Following this action there was a resumption by the tracheal trunks of their original form, but this action took place more slowly than the expiration. The interval from one exhalation to the next was approximately two seconds. It must be remembered that this could not be considered a normal breathing rate since all of these observations were made immediately following short periods during which the larva had been imprisoned away from air. The muscles or motivating force which caused the respiratory activity of the tracheal trunks defied detection.

*Since the investigations on which the present paper is based were completed there have appeared two papers by M. O. Lee: "The Function of the Air Sacs in Holopneustic Insects," in *Science*, LXIX, pp. 334-335, March 22, 1929; and "Respiration in the Insects" in *Quarterly Review of Biology*, IV, pp. 213-232, June 1929. Doubtless the function of the enlarged tracheal trunks in *Eristalis arbustorum* and allied species is the same as Lee suggests for air sacs, namely, a mechanical aid to respiration in allowing a considerable volume of air to be inhaled and exhaled.

Barlow (1) observed that respiration in dragon-fly adults varied from a very few movements per minute to as high as one hundred eight per minute. His conclusions were that the respiratory movements in the dragon-fly were subject to considerable variation in force and rate and that they were always quickened by exercise, emotion, rise of temperature, galvanism, and mechanical irritation.

Since Swammerdam in the seventeenth century discovered the presence of air sacs in insects, it has been generally assumed that their function is mainly for storage of quantities of air. To the writer it seems plausible that the enlarged portion of the tracheal system in this particular insect may be an adaptive structure serving the same purpose or purposes as air sacs in other insects. In view of the observations recorded above regarding the mechanics of the respiratory process in the tracheal trunks, it seems possible that the air sacs in other insects may function in the pumping process in a manner similar to the pumping in *Eristalis arbustorum*.

Function of Anterior Stigmatic Horns.

Metcalf (11) says that Syrphid larvæ typically have both anterior and posterior spiracles. Buckton (2), reporting his observations on *Eristalis arbustorum* larvæ, says he was never able to trace a tracheal connection to the opening of the anterior respiratory cornua. These structures are to be called stigmatic horns in the present paper in preference to Buckton's term. Metcalf takes exception to Buckton's statement and, in support of his view, states that if a larva is submerged and compressed, bubbles of air may be seen to form in connection with the tooth-like lobes (of the stigmatic horns). Wahl (20) makes the simple statement that there are posterior spiracles only in *Eristalis tenax* and proceeds on the assumption that he is dealing with a metapneustic insect.

The writer has not observed that the larvæ of *Eristalis arbustorum* ever normally use these anterior stigmatic horns for respiration. Certainly the larvæ while buried in mud in their natural habitat could not use them for respiration. To settle the question as to whether they are true spiracles or not, the following test was performed with several larvæ. A thick colloidal material was prepared by mixing cherry-gum with water. Each larva was placed in this and its actions noted.

Apparently the material offered so much resistance that the breathing tube (posterior) could not be raised to the surface for air. After considerable squirming the larva arose head first to the surface and placed the anterior stigmatic horns in contact with the atmosphere. At this instant in every case the larva ceased squirming and respiration began. The respiratory process in these tests took place in precisely the same way as described in the account previously recorded (p. 741) concerning the rate of respiration. The only observable difference was that, in that case, air was received from the posterior spiracles whereas, in this case, air was received from the anterior spiracles.

In order to determine whether respiration took place at a normal rate through the anterior stigmatic horns, respiration counts were made. The following table represents successive counts made on two different larvæ in the cherry-gum material. The counts listed in column A were made during the first few minutes after the larvæ had succeeded in bringing their anterior stigmatic horns into contact with the atmosphere following a period of submergence. The counts listed under column B were made during the first few minutes following a similar period of submergence. In the latter case, however, the larvæ had to be mechanically assisted in bringing the ends of the breathing tubes to the surface.

TABLE II.
COMPARISON OF RATES OF RESPIRATION.

	Respiratory Movements per Minute	
	A Through Anterior Spiracles	B Through Posterior Spiracles
Larva No. 1.....	24	22
	22	24
	22	22
	18	20
Larva No. 2.....	18	24
	18	18
	18	16
	12	16

No very marked differences can be detected in the rates of respiration. Undoubtedly, then, we might consider the

anterior stigmatic horns to be structures which at one time may have been normally used for respiration, at least part of the time by this insect, but which at present are used only when necessity demands. It is easily seen, then, that this insect has the amphipneustic type of respiratory apparatus instead of the metapneustic as some authors have suggested. However, regardless of this fact, this insect normally functions as a metapneustic form only.

Function of Retractable Processes.

Several of the tests already reported in this paper were planned partly with the idea of determining whether or not the retractile processes (Plate I, Fig. 1 and Fig. 7) had any connection with the respiratory function. These tests as they apply to this phase of the problem will now be discussed.

DISCUSSION OF TESTS.

Resistance to lack of oxygen.—It was thought that, if the retractile processes acted as supplementary respiratory organs, then, by placing the creature in an environment lacking oxygen, these organs would be brought into play. As far as could be observed none of the larvæ tested under these conditions (p. 739) attempted to use the retractile processes to supplement the oxygen supply.

Resistance to Carbon dioxide.—The larvæ, used in this series of three tests (p. 740) when placed in carbon dioxide were not observed by the writer to make any attempts to use the retractile processes for respiration. It seems probable that in their natural habitat an excess of carbon dioxide might occur. This test was planned with the idea of imitating this natural condition if it does exist.

Method and rate of respiration.—It will be recalled that in this test (p. 741) the larvæ were placed in a small quantity of water in the cell of a microscope cell-slide in such a way as to be shut off from an air supply. Under these conditions it would seem that accessory organs, if present, would be brought into play in order to obtain air from the water. No attempts to use the retractile processes were noted.

Closed spiracles.—One more simple test will now be described. Several larvæ were removed from water, and the tips of their

breathing tubes dipped in melted paraffin in order to close the spiracles. These larvæ were then placed in water again and observed at intervals for four hours. A check lot of untreated larvæ was also observed during the same time. The larvæ with spiracles closed could not be observed to perform differently from those with spiracles in normal condition. No larvæ of either lot attempted to extrude the retractile processes.

SUMMARY.

1. The larva of *Eristalis arbustorum* L. obtains its air supply normally through the posterior pair of spiracles which are located at the tip of the tail-like breathing tube.

2. The anterior stigmatic horns function as spiracles when necessity demands; therefore the larva has the amphipneustic type of respiratory system.

3. In addition to the two pairs of functional spiracles there are eight pairs of atrophied spiracles in evidence.

4. The two main longitudinal tracheal trunks are greatly enlarged throughout much of their length. The enlargements have taenidia in their walls, and consequently are not true air sacs.

5. In the breathing process exhalation takes place by a collapsing and shortening of the main tracheal trunks. The muscles or other apparatus which initiate this activity were not observed.

6. Under the conditions of the tests, the rate of respiration varied between twelve and thirty exhalations per minute.

7. Several tests designed to induce larvæ to use the retractile, finger-like, anal processes as tracheal gills gave negative results, and no evidence was obtained in support of the theory that this insect has both open and closed respiratory systems.

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EXPLANATION OF PLATES.

PLATE I.

- Fig. 1. *Eristalis arbustorum* larva, side view, showing tail-like breathing tube and retractile processes extruded from anus.
- Fig. 2. Tip of breathing tube showing the feather-like setæ.
- Fig. 3. End view of tip of breathing tube showing openings and feather-like setæ.
- Fig. 4. (a) One of anterior stigmatic horns showing tooth-like lobes. (b) Stigmatic felt from spiracle opening of the stigmatic horn.
- Fig. 5. Diagrammatic drawing of larva to show position of main tracheal trunks.
(a) Anterior section of main tracheal trunk showing its bent position.
(p) Posterior section of main tracheal trunk showing its bent position.
- Fig. 6. Tracheation of ventral body-wall of anterior end of larva. (I, II, and III) Attachments of ventral tracheæ to main longitudinal trunks.
(alc) Anterior commissure. (c') Accessory tracheal branch. (Imb) Imaginal bud attachment to body-wall. (j) Anterior spiracular connective. (n) Sternal trachea. (o) Ganglionic trachea. (o') Accessory ganglionic trachea. (p') Leg trachea.
- Fig. 7. Retractable processes as they appear while extruded from anal opening, (ventral aspect). (an) Anus. (ba) Basal part. (fi) Finger-like process. (ti) Smaller retractile tip of finger-like process.
- Fig. 8. Diagrammatic drawing of enlarged portion of a main tracheal trunk in inflated condition showing position of taenidia.
- Fig. 9. Same as Fig. 8, but showing position of taenidia at termination of an expiration.
- Fig. 10. Hypothetical primitive respiratory unit. (sp) Spiracle. (spp) Spiracular pit. (spt) Spiracular trunk. (st) Sternal trachea. (lt) Leg trachea. (pt) Pleural trachea. (gt) Ganglionic trachea. (asc) Anterior spiracular connective. (adc) Anterior dorsal connective. (pdc) Posterior dorsal connective. (alt) Anterior latero-tergal trachea. (plt) Posterior latero-tergal trachea. (adc) Tip of anterior dorsal connective. (tpdc) Tip of posterior dorsal connective.

PLATE II.

Dorsal view of *Eristalis arbustorum* larva showing especially the tracheation of the dorsal body-wall.

(I-X) Attachments of spiracular trunks to main longitudinal trunks.

(1-8) Dorsal connectives.

(A) Minor visceral trachea.

(B) Main visceral trachea.

(C) Spiracular trunk.

(as) Accessory trachea from anterior tracheal commissure.

(A/c) Anterior commissure.

(e) Fat-body trachea.

(f) Posterior branch of dorsal connective.

(fla) Tracheæ to retractile processes.

(g) Anterior branch of dorsal connective.

(h) Minor commissure.

(j) Anterior spiracular connective joined with leg trachea to form lateral trunk.

(k) Atrophied spiracle.

(m) Posterior latero-tergal trachea.

(n) Sternal trachea.

(o) Ganglionic trachea.

(p) Leg trachea.

(P/c) Posterior commissure.

(s) Anterior latero-tergal trachea.

PLATE III.

Part of internal anatomy of *Eristalis arbustorum* larva showing especially the tracheation of alimentary canal, salivary glands, Malpighian tubes, fat-body, and part of tracheation of nervous system. Ventral view of right main tracheal trunk.

(I-X) Attachments of spiracular trunks to main longitudinal trunks.

(A) Minor visceral trachea.

(A') Minor trachea to breathing tube.

(a) Branch of accessory trachea to ganglionic mass.

(B) Main visceral trachea.

(Ba) Accessory visceral trachea.

(C) Spiracular trunk.

(At) Head atrium.

(Ph) Pharynx.

(Sg) Salivary gland.

(Oe) Oesophagus.

(Br) Brain.

(Soe) Ganglionic mass.

(Mlg) Gland of Malpighian tube.

(Gc) Gastric caecum.

(Pr) Proventriculus.

(St) Mid-intestine (stomach).

(Fb) Fat-body.

(Mt) Malpighian tubes.

(Hi) Hind intestine.

PLATE IV.

Lateral view of *Eristalis arbustorum* larva in distended condition showing part of respiratory system.

(I-X) Attachments of spiracular trunks to main longitudinal trunks.

(1-8) Dorsal connectives.

(C) Spiracular trunk.

(j) Anterior spiracular connective.

(k) Atrophied spiracle.

(m) Posterior latero-tergal trachea.

(n) Sternal trachea.

(o) Ganglionic trachea.

(p) Leg trachea.

(s) Anterior latero-tergal trachea.

(t) Spiracular trunk from spiracle at tip of breathing tube.

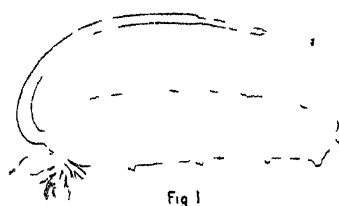


Fig 1



Fig 2



Fig 3

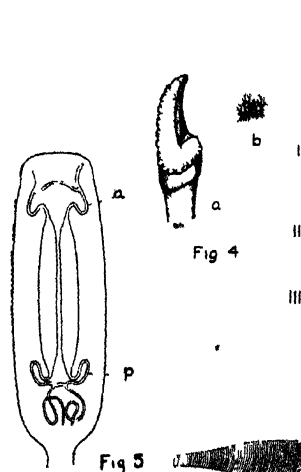


Fig 4

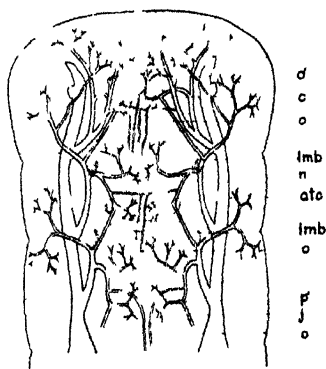


Fig 5



Fig 6

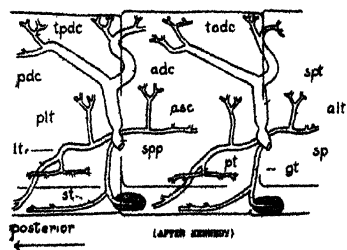


Fig 7

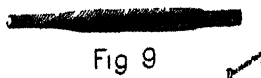


Fig 8

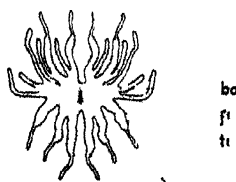
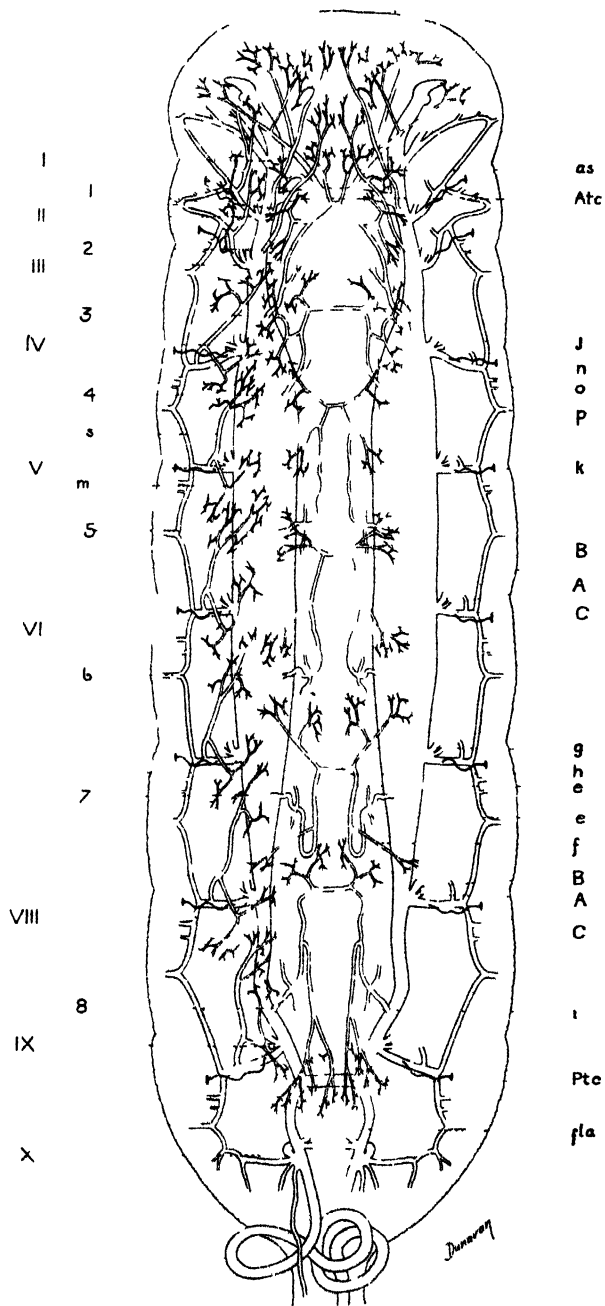
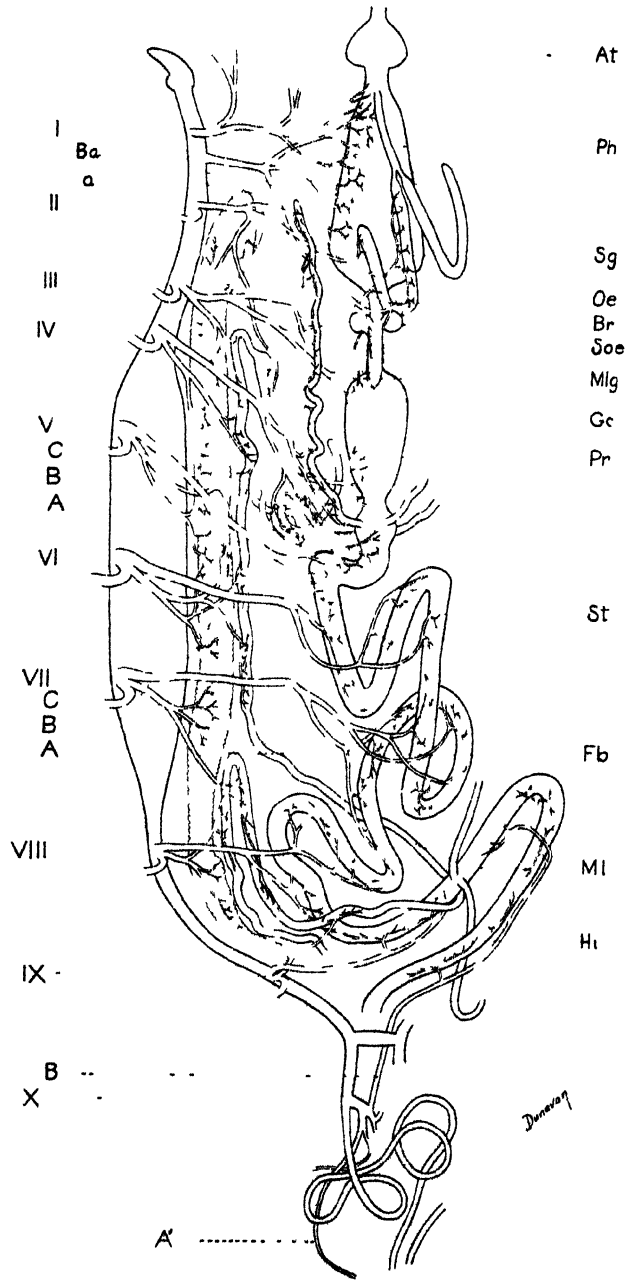
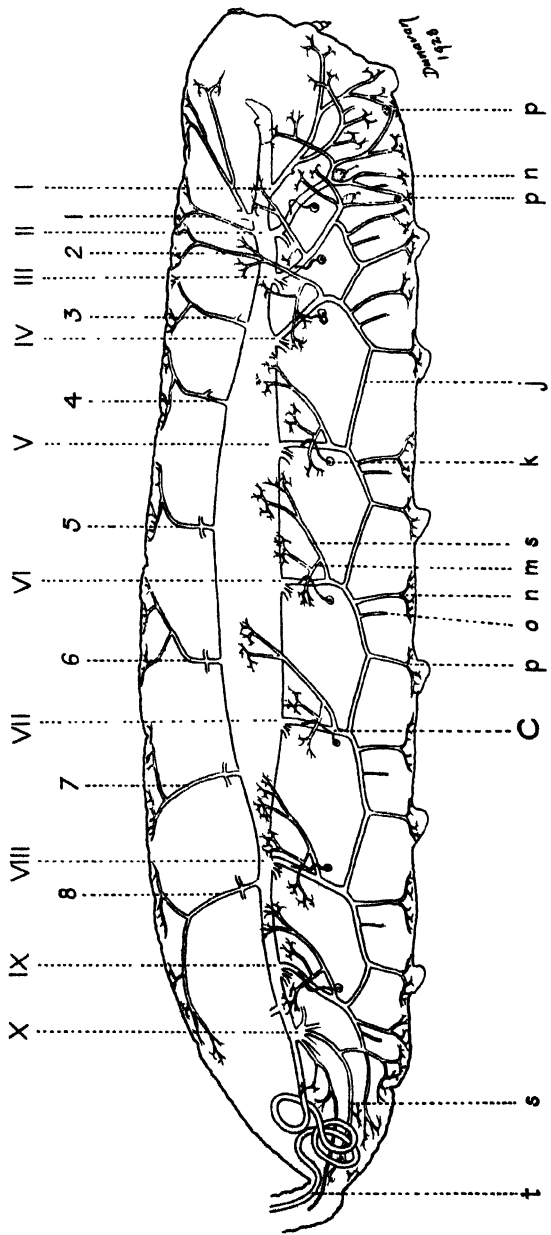


Fig 9







SOME BEES OF THE GROUP TRACHANDRENA, ROBERTSON (HYMENOPTERA: ANDRENIDAE).

T. D. A. COCKERELL

Robertson, in 1902, undertook to break up *Andrena*, as then understood, into six genera represented in the Illinois fauna; of these *Trachandrena* stood out as a very distinct group, and one would like to accept it as a full genus, but for the difficulty of limiting it accurately when dealing with the species of the Holarctic Region. Viereck, in 1924, recognized *Andrena* as a genus including eleven subgenera, dividing Robertson's *Trachandrena* into two parts, one of which he called *Scrapteropsis*. While this treatment did not seem very illuminating, it was probably a move in the right direction, and no doubt we shall have to accept a large number of subgenera, convenient for the grouping of the species, but not to be raised to generic status.

The tables of Robertson (Trans. Amer. Ent. Soc. XXVIII, p. 189) and Viereck (Guide to Insects of Connecticut, Part III) make the recognition of the species of the Eastern United States fairly easy. In the west there are doubtless many species still to be described, and such tables as have been published by Viereck and by myself represent only fragments of the fauna.

There are some outstanding questions which it is worth while to discuss:

(1) The western group of *A. mellea* Cress., *A. prunorum* Ckll., *A. argemonis* Ckll. stands near *Trachandrena*, but is really distinct. The male of *A. prunorum* has a yellow clypeus. These bees are extremely similar to some which inhabit the drier parts of Asia, as I hope to show in detail later on.

(2) *Andrena mariæ* Rob. extends west into Colorado, but in the Rocky Mountains gives off segregates, *A. sphecodina* Casad. & Ckll. (New Mexico), and *A. martialis* Vier. & Ckll. (Colorado), which may perhaps best be regarded as of sub-specific rank.

(3) *A. ceanothi* Vier. and *A. heraclei* Rob. are very close, but distinguishable.

(4) *A. multiplicatiformis* Vier. is represented in the extreme northwest by the earlier described *A. grandior* Ckll., having the first tergite more strongly punctured apically.

(5) *A. imitatrix* Cres., based on three females from Texas, appears to include within specific limits the forms called *texana* Cress. (male from same lot as *imitatrix*), *profunda* Vier., and *claytonia* Rob. In the male, it seems that *claytonia* is smaller than *profunda*, with clear amber stigma. In the female, some placed with *claytonia* have an evident median raised line or keel on clypeus, and some lack this. In his original description Robertson said, "clypeus often with a median impunctate line." It may be suspected that there is in reality a little group of closely allied species, but if so, the matter has yet to be elucidated.

(6) *A. hippos* Rob. is represented in Colorado by *A. perforatella* Ckll., smaller, with the hair marks at sides of abdomen very pure white. I think *perforatella* cannot rank as more than a subspecies.

(7) *A. forbesii* Rob. has been held to include *A. weedi* Viereck. On comparing specimens I find them closely allied but distinct. Thus in *A. forbesii* the raised portion of the second tergite is quite closely and evenly punctured all over, while in *weedi* this part is polished, with weak indefinite punctures. My *A. weedi* are from Waldoboro, Maine (Lovell).

These insects have been carefully collected in only a few places. The subject is now advanced sufficiently to make the study attractive and not too difficult. The flower visiting habits and times of flight have been set forth for Illinois in great detail by Robertson, and for Wisconsin by Graenicher. The tendency to form local races or subspecies, already evident, should be further investigated, and we should find out whether these differences are associated with peculiarities of climate or differences in the flower, visited, or both.

***Andrena (Trachandrena) rodecki* sp. n.**

♀ Length about 9.5 mm., anterior wing, 7.5 mm.; black, robust, the head and thorax with rather abundant erect pale grey hair, ochreous on vertex, and tinged with ochreous on scutellum and more or less on posterior part of mesothorax; malar space very short; mandibles black; process of labrum large, broadly truncate, the sides sloping rapidly; facial quadrangle about square; clypeus convex, hairy all over, coarsely rugose, punctate, the apical middle shining, no ridge or smooth

line; antennæ black, third joint densely pitted, not as long as next two combined; facial foveæ broad, pale, with a faint ochreous tint. extending below level of antennæ, separated by a shining line from eye; mesothorax and scutellum dullish, coarsely and densely punctured, the mesothorax minutely tessellate between the punctures; area of metathorax strongly irregularly plicate, broadly truncate behind; mesopleura dull, rugoso punctate; tegulæ reddish black, strongly hairy; wings greyish hyaline, dusky at apex; stigma moderate, bright ferruginous, with broad darker margin; nervures dilute fuscous; basal nervure meeting nervulus; second cubital cell rather broad, receiving recurrent nervure a little beyond middle; legs black, with pale hair, hind tibiæ and tarsi ferruginous; tibial scopa pale, shining white in an oblique light; abdomen convex, shining, finely but very evidently punctured, first tergite closely punctured, second depressed in middle a little more than half; tergites 2 to 4 with lateral white hair bands on fourth not very broadly interrupted; apical tuft bright clear orange ferruginous.

Geneva Park, Boulder, Colorado, May 14, 1929. (Hugo Rodeck). Closely related to *A. heraclei* Rob. (specimen from Algonquin, Ill., compared), but tegulæ dark, mesothorax much duller and more closely punctured, hind margins of tergites black. The large separated punctures on middle of clypeus readily separate it from *A. spiraeana* Rob.

***Andrena (Trachandrena) spiraeana* Robertson.**

Boulder, Colorado, June, 1929. (Norma LeVeque). New to Colorado.

***Andrena (Trachandrena) forbesii* Robertson.**

Boulder, Colorado, May 24. (Maxy Pope). New to Colorado.

***Andrena (Trachandrena) multiplicata* Cockerell.**

Boulder, Colorado, June 6, 1919. (Doris G. Roberts). New to Colorado.

Of the thirteen species of *Trachandrena* taken at Boulder, six are identical with species taken by Robertson at Carlinville, Illinois. Carlinville has eleven species. In Milwaukee County, Wisconsin, Graenicher took eight species of *Trachandrena*, of which five were common to Carlinville, and four occur at Boulder. One of the Wisconsin species (*A. multiplicata*) occurs at Boulder, but not at Carlinville.

***Andrena (Trachandrena) obscura* Robertson.**

♀ Length about 10 mm., anterior wing, 7.8; black, robust, the head and thorax with rather thin dull white hair, clear white and conspicuous at sides of face and of metathorax; malar space linear; mandibles black; process of labrum broadly truncate; facial quadrangle about square; clypeus shining, but closely and strongly punctate, with a more or less evident smooth middle line; facial foveæ rather broad, their pubescence white, foveæ extending below level of antennæ, but about middle is a broad shining space between fovea and eye; vertex shining, with scattered punctures; antennæ with fourth joint not quite as long as next two combined; flagellum very dusky reddish beneath, its basal joints rugose; mesothorax and scutellum shining, but not highly polished, with large scattered punctures; area of metathorax strongly plicate, the sides adjacent very coarsely reticulate, just above the white fringe; mesopleura coarsely sculptured; tegulæ large, nearly black, shining dark rufous posteriorly; wings hyaline, slightly reddish, stigma and nervures dark reddish brown; basal nervure meeting nervulus; second cubital cell receiving recurrent nervure slightly beyond middle; legs black, spurs ferruginous; tibial scopa white; abdomen shining, finely punctured, weakly and rather sparsely on first tergite; second tergite in middle depressed more than half; tergites 2 to 4 with clear white hair bands at sides only; apical tuft dilute chocolate.

Falls Church, Virginia, July 4 (Cockerell). Resembles *A. spiraeana* Rob., *A. ceanothi* Vier., and *A. multiplicatiformis* Vier., but quite distinct. I had decided to describe it as a new species, as it seems different from my only specimen of *A. obscura* Rob., unfortunately a male, determined by Viereck. The matter was rendered more obscure from the fact that Robertson introduced his *obscura* (1902) in a few words in a table only, and did not know the male. I discover from Robertson's recent book that the type of *A. obscura* was from flowers of *Pycnanthemum*, a plant which begins to bloom at Carlinville June 19. Moreover, Viereck records *A. obscura* at Colebrook, Conn., July 21. There are very few *Trachandrena* flying as late as July, and putting together all the fragments of evidence, I am now convinced that my supposed new species is in fact *A. obscura*, which may I hope be rescued from its obscurity by a recognizable description.

***Andrena (Trachandrena) indianensis* sp. n.**

♀ Length about 10.5 mm.; black, unusually slender, hair of head and thorax thin and dull white, not at all ochreous; malar space obsolete; mandibles red at apex; process of labrum large, truncate apically, with very gradually sloping sides; head very broad, facial quadrangle broader

than long; clypeus shining, strongly but not very densely punctured, somewhat flattened and more sparsely punctured in middle; facial foveæ dull white, very broad above, almost reaching lateral ocelli, only little narrowing below to end below level of antennæ, and separated from eye by a shining line; front rugose, vertex dull; antennæ black, with third joint shorter than next two combined; hair of thorax above thin and outstanding (not at all velvety); mesothorax dullish, with rather close small but distinct punctures, between which the surface is minutely tessellate; scutellum shining, not densely punctured; area of metathorax dull and poorly defined, very coarsely and irregularly rugosoplicate; mesopleura dull and densely rugulose; tegulæ anteriorly black, posteriorly shining reddish; wings hyaline, faintly reddish; stigma large, uniform dusky red; nervures rather dilute fuscous; basal nervure falling short of nervulus; second cubital cell large and broad, receiving recurrent nervure at middle; legs black, the tarsi brownish apically; scopa of hind tibia loose and white, the hairs on outer face simple, strongly bent (the pollen collected is very pale, and does not belong to the Compositæ); abdomen broad and flattened, shining, finely but distinctly punctured, without bands, the apical tuft light greyish brown; first tergite distinctly punctured all over; second depressed less than half, the edge of the depression straight; some thin pale hair placed obliquely at sides of tergites 2 to 4.

4 ♀ ♀, Bloomington, Indiana, (Ellis). Rather like *A. crataegi* Rob., but conspicuously less robust, with hair on inner side of hind basitarsi white, and sculpture of head and thorax different.

BOOK NOTICE.

A MANUAL OF EXTERNAL PARASITES, by Henry Ellsworth Ewing. Charles C. Thomas, publisher.

This book includes keys to most of the genera in the groups that are externally parasitic, limited to the mites, ticks, biting lice, sucking lice and fleas. More particular attention has been given to those which have the greater economic importance and the work is intended as a hand-book for students, veterinarians and medical men interested in these forms. The illustrations, which are quite profuse are, many of them, from the accurate drawings of the author and will be of great service in recognizing the characters used in the keys, as also for certain of the species. While not intended as a treatise on the control of parasites, but rather as a means of recognition for them, it includes in many instances the recognized methods of treatment. A point which should have the attention of taxonomists is that a number of new genera are described and the author justifies their inclusion in the Manual for the reason that they are associated with the keys to the groups to which they belong. On this account it is the more important that the work be fully noted in bibliographical records. The author had the distinct advantage of access to all the important collections in these groups which are under his care in the National Museum. H. O.

A NEW VELIA FROM ARIZONA WITH NOTES ON OTHER SPECIES

(HEMIPTERA - VELIIDAE)

H. B. HUNGERFORD,

Department of Entomology, University of Kansas.

For the past three summers Entomological expeditions from the University of Kansas under the field direction of Doctor R. H. Beamer have been made into the southwestern part of the United States. Besides making rich additions to the collections made by Dr. Francis Huntington Snow many years ago, Doctor Beamer and his assistants have added many undescribed insects. One of them is described below:

Velia beameri species new

Size: Length 6.6 mm. to 7 mm.; width across head 1.2 mm.; width across front margin of prothorax 1.7 mm.; greatest width 2.8 mm.

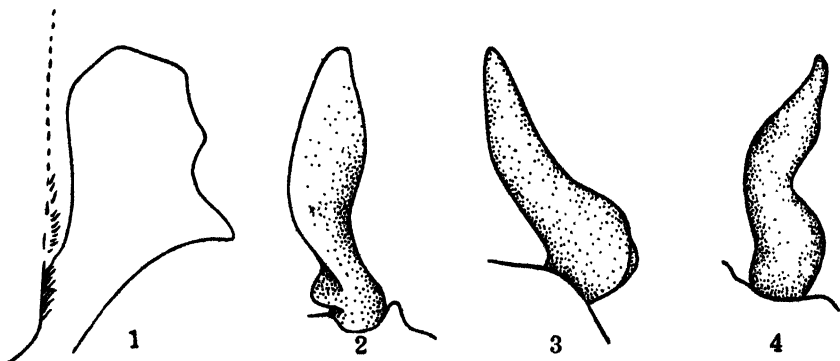
Color: Chocolate brown with two silvery triangular patches on pronotum, silvery transverse bands on segmental lines of the connexivum, slender median streak of silver on dorsum of first two abdominal segments, silvery hairs on last four abdominal segments arranged in a more or less definite inverted U; venter brown, frosted, with silvery patches at bases of acetabula and on sides of abdomen; Antennæ brown; legs contrastingly banded—pale horn and dark brown, coxæ, trochanters and basal half of femora pale horn with slight infuscation on rear side of trochanters and bases of femora of front and middle legs. Outer half of femora and distal segments dark brown banded with pale horn as follows: A pale band in middle of dark outer half of femora—a small faint one at base of tibiæ, a broad one near the middle of the tibiæ and another covering most of the second tarsal segments of the middle and hind legs.

Structural characteristics: A robust species with the anterior part of pronotum distinctly wider than the head. Rear margin of pronotum (apterous form) broadly rounded, semicircular. Pronotum pitted, calli elevated, faint median longitudinal carina on pronotum. Antennæ formula as follows: 1st:2nd:3rd:4th::9:5:5.5:5. (In the third segment I have counted the short intersegmental segment). Interocular space slightly wider than an eye. Body and limbs covered with hairs about as in *Velia brachialis*—Stål. Genital claspers of the male something like those of *Velia brachialis*—Stål.

Described from a male and female from Santa Rita Mountains, Arizona. Taken by Doctor R. H. Beamer July 24, 1927.

Holotype and allotype in the Entomological collection of the University of Kansas.

Comparative notes: This species I had determined to be *Velia annulipes* Champion but in comparing it with the type in the British museum I found it to be slightly larger, of different color from Champion's species and to possess a male genital clasper of decidedly different shape. Champion's male type is reddish brown in color with nearly black patches on the anterio-lateral angles of the prothorax. The head is broader than in my species and body not as broad. The antennæ have lost the last two segments but the formula for the basal segments is: 1st; 2nd::3.25:2 and the basal segment is longer, straighter and more slender than in the female specimen of my species



LEFT MALE GENITAL CLASPERS OF SOME VELIA.

1. *Velia Annulipes* Champ.
2. *Velia conata* Hungerford.
3. *Velia beameri* Hungerford.
4. *Velia brachialis* Stal.

with which I compared it. The hind femora of Champion's type are about the same thickness with only about ten slightly thicker and a little more prominent spines. The shoulders of the type are raised and the anterior central elevation of the pronotum is crescent shaped, smoother and flatter than in my species and continued behind by a broad carinal base. In the Museum at Vienna I found two specimens marked "Cotypes" "Mexico Coll. Signoret" one labeled "Sp. fig. by Champ. = ♂." In this male which is wingless and considerably smaller than my species, the first segment of the antenna is long and thin and appears as long as pronotum (this is not true of the female

however). In the male, what appears to be the fifth ventral abdominal segment is produced behind beyond the rear margin of the next segment. The middle tarsal segment of middle tarsus is longer than terminal (using short side of terminal) otherwise they are subequal.

Velia beameri species new is larger and different shape from *Velia brachialis* Stal., the type of which I have seen in the Museum at Stockholm. *Velia brachialis* Stal. was described from Rio Janeiro but I have compared with the type some specimens from Colorado County, Texas, taken by Mrs. Grace Wiley and they are identical.

The *Velia* of the Western Hemisphere appear to fall into several groups. One group is so distinct from the species first described in the genus that I recently separated it under the subgeneric name *Stridulivelia*. Other natural groupings are:

II. The *Velia stagnalis* Burm. group which includes also *Velia watsoni* Drake and *Velia virgata* White.*

III. The *Velia basalis* Spinola group for which Breddin proposed the genus name *Paravelia* but to which his own species, *Paravelia boliviana* Breddin does not, I believe, belong.

IV. The *Velia inveruglas* Kirkaldy group which resembles more than any of the others, the European *Velias*. Through the very great kindness of Dr. Alfredo Borelli I was permitted to examine the type of *Velia inveruglas* Kirkaldy in the Museum of Zoology of the University of Turino. I can find no structural characteristics to distinguish *Velia osborniana* Kirkaldy, (new name for *Velia brunnea* Osborn), from it. *Velia albotrimaculata* Kirkaldy, the female type of which I studied in the Royal Museum at Brussels, belongs in this group and perhaps also a smaller but beautiful species with an orange red head and pronotum and three white spots on black wings which I described in the Museum at Stockholm under the name of *Velia helenæ*.

V. The *Velia brachialis* Stal. group which besides *Velia annulipes* Champ. and *Velia beameri* includes *Velia conata* Hungerford, an interesting and characteristic species that is a little smaller than *Velia brachialis* Stal., has somewhat the same general appearance but is distinguished by a conate elevation on the pronotum.

*I have examined the type of White's *Velia vivida* and find it to be a *Rhagovelia*.

TWO NEW SPECIES OF ERIOCOCCUS FROM MISSISSIPPI.

(Homoptera: Coccoidea).*

With two plates and eleven figures.

GLADYS HOKE LOBDELL,
A. & M. College, Mississippi.

Descriptions of two species of the genus *Eriococcus* are presented at this time for publication in anticipation of the use of the names in a forthcoming paper on some scale insects of Mississippi.

Mr. E. E. Green (Coccidæ of Ceylon, Pt. V, page 345, 1922) gives the group sub-family rank as the *Eriococcinæ*. He says, however, "I have treated this group as a separate family." As members of the genus *Kermes* are recognized as being of the Eriococcine type and are placed in the subfamily, or family as it is here designated, with *Eriococcus*, it seems advisable to use the name *Kermesidæ* in preference to *Eriococcidæ* for this group. *Eriococcus* was first used as the name of a genus by Targionia in 1869. The genus *Kermes* is credited to Boitart, Manual d'Entomologie, 1828, and, although I have not had the privilege of examining the publication, the name is generally accepted for the genus, apparently having been substituted for the term *Chermes* which had been previously used for an aphid by Linnaeus.

Kermesidæ.

This group, which I am treating as a family and calling the *Kermesidæ*, is characterized by the presence of conspicuously prominent anal lobes, at least during the larval stage (as in *Kermes*), which persist in some genera in the adult stage (as in *Eriococcus*); antennæ with not more than seven segments, the distal segment short, not of the Pseudococcine type; tarsus relatively long, usually as long as or longer than the tibia; the anal ring bearing setæ in at least the larval stage of development (as in *Kermes*), which frequently persist in the adult stage (as in *Eriococcus*).

*Contribution from the Entomology Laboratory of the Mississippi Agricultural Experiment Station and the State Plant Board of Mississippi.

***Eriococcus pilosus*, new species.**

Sac of Female.—Female enclosed in a tough yellow-white felted sac, 3.5 mm. long, outer part of case of loose woolly fibers; dead insect, deep red color, turning lighter and brighter in KOH and easily losing its color; KOH solution colored for short time around specimen; dried body of insect without waxy powder; spines of dorsal surface quite noticeable under low power binocular when in KOH.

Adult Female.—Body of specimens examined 2 to 2.64 mm. long, .6 to 1.5 mm. broad; elongated, tapering towards ends; derm membranous except portions of anal lobes; antennæ seven-segmented, basal segment slightly broader than long, much shorter on lateral aspect than on mesal, as long as or slightly longer than fifth and sixth segments, which are subequal, third and fourth longest, subequal, fourth often with indication of pseudosegmentation, distal segment bearing about nine to eleven long stiff setæ, third segment apparently without setæ, others usually with two or more setæ on distal half; legs tapering, coxæ large, longer than broad, each trochanter bearing a stiff tapering seta, slightly longer than coxa itself or longest ventral thoracic setæ, femur broadest through middle, tibia and tarsus subequal in length, very slender, claw with small denticle, ungal digitules slender, tarsal digitules similar but larger, both dilated at distal end, each hind coxa with about 25 to 35 large pores on posterior ventral surface; spiracles small, only slightly narrower in center than at ends; tentorium compact, heavily chitinized, rostrum two-segmented; dorsal surface with a number of long tubular ducts, each opening to surface through pore with non-chitinized rim, usually difficult to detect, distal or ental end of larger part of duct cup-shaped and chitinized, continuing as a smaller duct from one edge of cup, this smaller and distal portion of duct very difficult to see in most specimens; numerous minute ducts (?) with chitinized rims on basal portions; ventral surface with ducts of same type but smaller; dorsal surface with numerous rather long and slender spines of two sizes, most numerous on head and thorax, apparently in three rows on each side, mesal rows in close proximity and giving the appearance of one double row, marginal row extending to anal lobe, mesal row extending on to sixth abdominal segment, two median spines on fourth, fifth, and sixth abdominal segments very much reduced and inconspicuous, on some specimens lateral row on these segments represented by a single inconspicuous spine, this row on head and thorax apparently usually consisting of two large spines and a small one transversely arranged, limits of rows not always readily discernible; ventral surface with a few long, slender setæ especially on meson, ducts of same type as those of dorsum, but smaller, multilocular pores and minute filiform projections on ventral surface of abdomen, most numerous in region of vulva; anal lobes long, slightly chitinized, bearing on dorsal surface three spines, a small one near base of lobe on mesal margin and two long ones near meson of lobe about size of large marginal spines; ventral surface of lobes with two slender setæ slightly longer than those on dorsal surface; a similar larger seta near cephalic end of anal ring and three or four

pairs on segments cephalad and caudad of vulva; eight anal ring setae, about two-fifths as long as anal lobe setae.

Host—Thistle, (*Cirsium* sp.) on under surface of dead leaves. Locality.—A. & M. College, Mississippi: February 14, 1927, Collected by Dr. M. R. Smith.

This species is probably more similar to *tinsleyi* Ckll., 1898, than to other species, though it resembles *stanfordianus* Ferris, 1920, in the definite arrangement of the dorsal spines.

Holotype in the Coccid collection of the Mississippi State Plant Board.

***Eriococcus smithi*, new species.**

Sac of female: 2.2 to 2.9 mm. long, .6 to 1.1 mm. broad, closely felted, tough, light brown color, flattened dorsally, dorso-lateral edges prominent, very convex ventrally, posterior margin with small dorsal opening; frequently unsymmetrical due to crowding, posterior end of one overlapping anterior end of the following one, these usually arranged along midrib on dorsal surface of leaf.

Sac of male: Usually 1.1 mm. long, .4 mm. broad; dirty white color, closely felted, but less so than in female, comparatively brittle, cylindrical or subcylindrical, ends bluntly rounded, posterior slightly flattened and thin; arranged on dorsal surface of leaf.

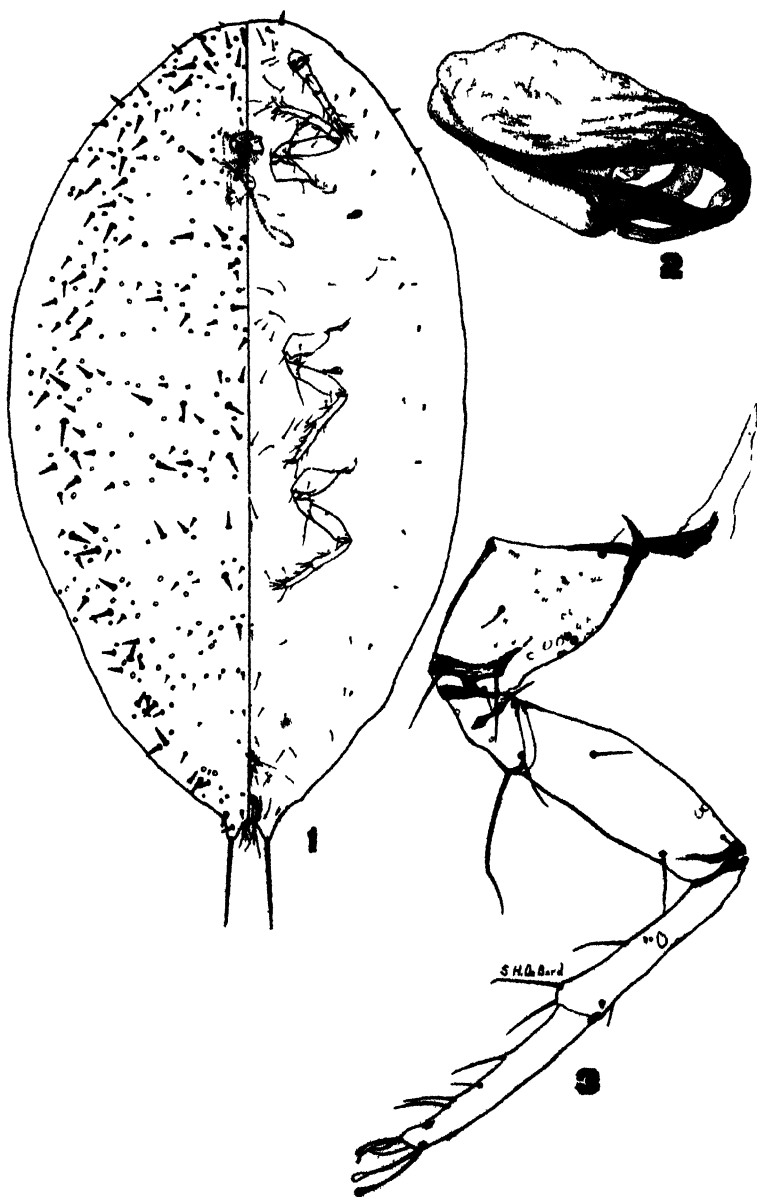
Adult Female.—Body mounted on slide 1.55 mm. to 2.07 mm. long, .59 mm. to .85 mm. broad; derm membranous except anal lobes; antennae usually seven-segmented, occasionally an antenna with five or six segments; legs long and slender, hind coxae with a few irregular clear areas varying in size, tibiae from three-fifths to four-fifths as long as tarsi, digitules longer than claws, claws long and slender; spiracles medium small and broad; tentorium as broad as long, rostrum as broad as long, about seven-eighths as long as tentorium; body with numerous tubular ducts, only the inside of cup chitinized, setae on dorsal and ventral surface arranged in transverse rows, dorsal shorter than ventral; a few multilocular disc pores, most numerous in region of spiracles and vulva; margin with long chitinized spines, ends truncate; anal lobes chitinized, outer, dorsal edge with one and inner with two spines of marginal type, ventral side with a short, a median, and a long apical seta, anal ring with eight setae about one-half as long as anal lobe setae.

Host.—Broom sedge (*Andropogon virginicus* L.). Locality: Meridian, Mississippi: November 14, 1927. Collected by Dr. M. R. Smith. Attended by Argentine ants (*Iridomyrmex humilis* Mayr.).

The sacs of the males and females are usually (?) segregated on different blades of grass, but occasionally male sacs are found associated with those of the females.

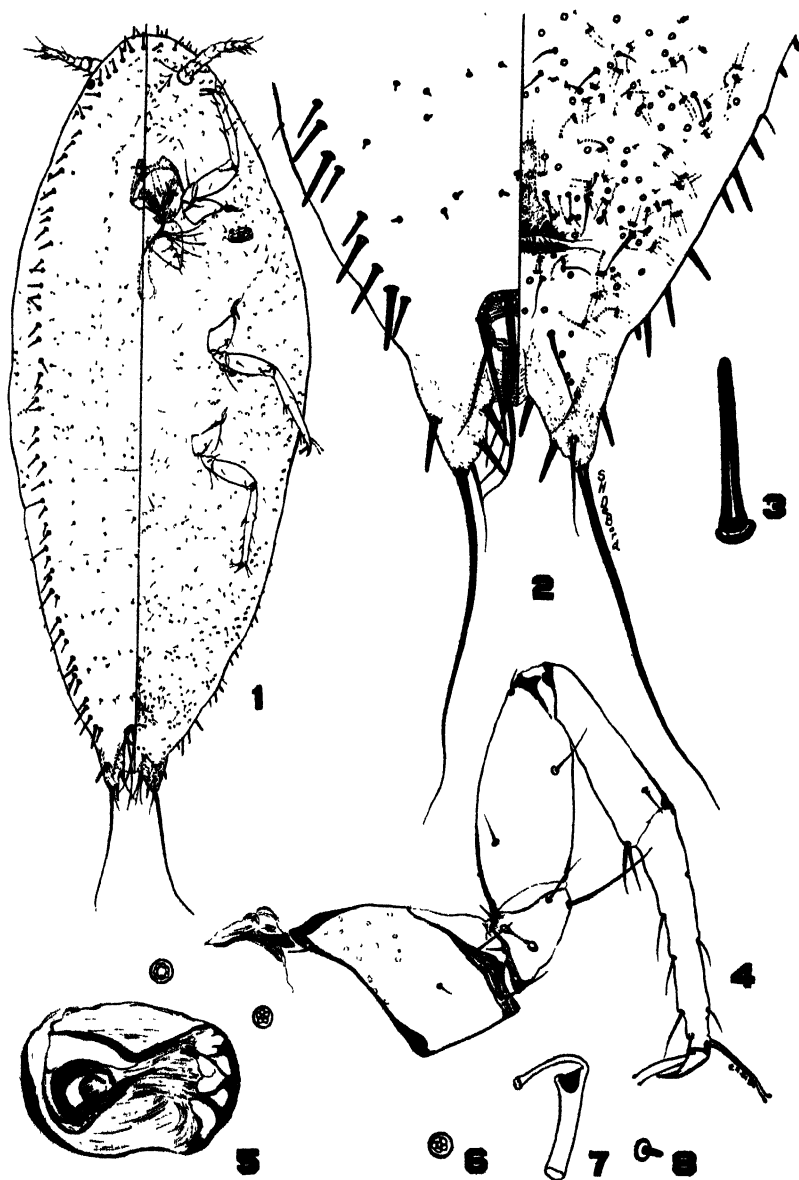
Dr. Morrison says, "This insect is undoubtedly very closely related to *Eriococcus kemptoni*, differing only in having the spines somewhat stouter and more blunt tipped at the apices and in having the large marginal spines suppressed in the middle part of the body."

Holotype in the Coccid collection of the Mississippi State Plant Board. Paratypes in the Coccid collection of the United States National Museum, Washington, D. C., and in the collection of the Mississippi State Plant Board.



Eriococcus pilosus, new species.

1, Adult female, $\times 58$; 2, Anterior spiracle, $\times 706$; 3, Hind leg, $\times 182$.



Eriococcus smithi, new species.

- 1, Adult female, $\times 64$; 2, Posterior end of abdomen, $\times 184$; 3, Marginal spine, $\times 683$;
4, Hind leg, $\times 273$; 5, Posterior spiracle, $\times 683$; 6, Pore, $\times 683$; 7, Duct, $\times 683$;
8, Dorsal body seta, $\times 683$.

NEW SPECIES OF CRANE FLIES FROM SOUTH AMERICA. PART III.*†

(Family Tipulidæ, Order Diptera).

CHARLES P. ALEXANDER,
Amherst, Mass.

The great majority of the species discussed at this time are from *Argentina*, collected by Messrs. Bruch, Shannon and Weiser; *Paraguay*, collected by Schade; and *Ecuador*, collected by Tate. The interesting *Tipula* is from *Colombia* and was included in extensive collections of crane-flies belonging to the British Museum, kindly loaned to me for study by Mr. Edwards. Except where stated to the contrary, the types of the new species are preserved in my collection.

Tipula Linnæus.

Tipula colombicola sp. n.

Belongs to the *macrosterna* group; nearly allied to *trinidadensis* Alexander; antennæ more elongate, nearly one-half the length of the body in male; three complete thoracic stripes; ninth tergite of male hypopygium with a quadrate median notch.

Male. Length about 13 mm.; wing, 12 mm.; antenna about 6 mm.

Frontal prolongation of head dark brown dorsally, heavily pruinose, the remainder light yellow; palpi chiefly obscure yellow. Antennæ more elongate than in *trinidadensis*, the scape light yellow; first flagellar segment black, the distal half yellow; remaining segments black, their extreme tips light yellow, the outer segments more uniformly darkened. Head obscure yellow, the center of the vertex conspicuously dark brown.

Mesonotal praescutum yellow, with three conspicuous shiny dark brown stripes; scutal lobes yellow, each variegated with two lighter brown areas; postnotum whitish pruinose. Pleura heavily white pruinose, the dorso-pleural membrane light yellow, dusky before the wing-root; a blackish spot on anepisternum. Halteres yellow, the base of the knobs darker. Legs with the coxæ pale, weakly pruinose; femora yellow, the tips very narrowly but conspicuously dark brown;

*Contribution from the Department of Entomology, Massachusetts Agricultural College.

†The preceding parts under this general title were published in these ANNALS in 1926 (XIX: 378-394), and 1928 (XXI: 623-641).

tibiæ brownish yellow, the tips very narrowly infuscated; tarsi elongate, pale brown, gradually passing to brownish black. Wings yellowish gray, the prearcular and costal regions bright yellow; stigma pale brown, a little darker than the ground-color; veins yellowish brown. Venation about as in other members of the *macrosterna* group.

Abdominal tergites reddish yellow, the intermediate segments with a shiny black median triangle; segments seven and eight black, to produce a subterminal ring; hypopygium large, fulvous-yellow. Male hypopygium with the median incision of the ninth tergite relatively deep and narrow, the lateral lobes directed caudad and mesad, blackened. Dististyles very complicated in structure; dorsal submedian lobe that is chisel-shaped in *trinidadensis* is here more acutely bispinous, the ventral spine longer and more conspicuous; the outermost style or blade is extended laterad into a conspicuous spine.

HABITAT: Colombia. *Holotype*, ♂, Lake Sapatoza Region, Chiriguana District, August-September, 1924 (C. Allen). Type in the British Museum (Natural History) No. 1925-576.

Limonia Meigen.

Limonia (Limonia) catamarcana sp. n.

General coloration brownish gray; antennæ brownish black, the first segment yellow; knobs of halteres darkened; legs chiefly obscure yellow; wings whitish subhyaline, sparsely variegated with brown; a supernumerary crossvein in cell *Sc*, close to *Sc*₂; *m-cu* before the fork of *M*; male hypopygium with the rostral prolongation of the ventral dististyle very high and compressed, the two spines placed on the side near the ventral margin.

Male. Length about 5.5 mm.; wing, 6.5 mm.

Rostrum obscure yellow, the palpi darker. Antennæ with the basal segment yellow, the remainder brownish black; flagellar segments oval. Head chiefly brownish gray, the front and occiput more yellowish.

Pronotum dark medially, paling to yellow on the sides. Mesonotal praescutum brownish gray, darker medially, the humeral region more brightened; scutal lobes dark brown, the median region and scutellum pale yellow; postnotum dark, pruinose. Pleura variegated brown and yellow, the surface pruinose; dorso-pleural region paler. Halteres pale, the knobs darkened. Legs with the coxæ obscure yellow, the fore coxæ darker; trochanters yellow; remainder of legs obscure yellow, the tarsal segments passing into dark brown. Wings whitish subhyaline, the oval stigma darker brown; restricted dusky clouds at origin of *Rs*, along cord and outer end of cell 1st *M*₂; veins dark. Venation: *Sc* ending some distance beyond origin of *Rs*, *Sc*₁ at about one-third the length of *Rs*, *Sc*₂ some distance from its tip; in both wings of

type and thus presumed to be normal, a supernumerary crossvein in cell *Sc* not far from *Sc*₂; *Rs* long, gently arcuated; cell 1st *M*₂ long and narrow; *m-cu* about one-third to one-half its length before the fork of *M*.

Abdominal tergites brown, the incisures pale; sternites more uniformly yellow; hypopygium chiefly pale. Male hypopygium with the caudal margin of the tergite gently emarginate, the lobes low, each with from eight to ten setæ. Basistyle with the ventro-mesal lobe short and stout. Ventral dististyle relatively small, the rostral prolongation very high and compressed, the caudal margin gently rounded to the blunt tip; the usual two spines short, placed laterally on the face of the prolongation near the ventral margin. Dorsal dististyle curved to the long acute tip. Gonapophyses with the mesal apical lobe unusually short and inconspicuous, the margin of the notch microscopically serrulate.

HABITAT: Argentina. *Holotype*, ♂, Quebrada "Volcan," at Agua Amarilla, Catamarca, January 29, 1922 (V. Weiser).

Limonia catamarcana is quite distinct from other regional species of the subgenus. The entire aspect of the fly is that of a *Dicranomyia* rather than a *Limonia*, but from the venation the species must be referred to the latter subgenus. It seems very possible that the presence and position of the supernumerary crossvein in cell *Sc* is not constant for the species.

***Limonia (Limonia) villaricæ* sp. n.**

General coloration dark brown; knobs of halteres darkened; legs chiefly obscure yellow; wings light brown, the stigma scarcely darker; *Sc*₁ ending about opposite two-fifths the length of *Rs*; *m-cu* longer than the distal section of *Cu*₁; male hypopygium with the rostral spines of the ventral dististyle two, subequal.

Male. Length about 4.6 mm.; wing, 5.3 mm.

Rostrum approximately one-half the remainder of the head, obscure yellow, darker apically; palpi brown. Antennæ with the scapal segments brown, a trifle paler than the brownish black flagellum; flagellar segments oval. Head brown, paler behind.

Mesonotum chiefly dark brown, the lateral margins of the praescutum and scutal lobes a little more reddish brown. Pleura similarly dark reddish brown. Halteres pale, the knobs dark brown. Legs with the coxæ brown, the trochanters obscure yellow; remainder of legs obscure yellow, only the last tarsal segment infuscated. Wings with a light brown tinge, the oval stigma scarcely darker, barely indicated; veins darker brown. Venation: *Sc*₁ ending about opposite two-fifths the length of *Rs*, *Sc*₂ not far from its tip; *Rs* arcuated to weakly angulated at origin; cell 1st *M*₂ small, shorter than the veins beyond it;

m-cu a short distance before the fork of *M*, longer than the distal section of *Cu*₁.

Abdominal tergites dark brown, the sternites yellow; hypopygium brownish yellow. Male hypopygium with the tergite transverse, the caudal margin very gently emarginate, with numerous coarse setæ. Ventral dististyle fleshy, the rostral prolongation stout basally, narrowed to the obtuse tip; rostral spines two, placed on basal half of the prolongation, subequal and placed close together. Dorsal dististyle a relatively short curved rod, the tip suddenly narrowed into an acute spine. Gonapophyses with the mesal apical lobe broad, narrowed gradually to a small, slightly decurved point, the margin irregularly and microscopically roughened.

HABITAT: Paraguay. *Holotype*, ♂, Villarica, August 26, 1924 (F. Schade).

Limonia villaricæ is a small, insignificant species, characterised especially by its negative characters and structure of the male hypopygium.

***Limonia (Dicranomyia) weiseriana* sp. n.**

General coloration gray; rostrum obscure yellow; wings whitish subhyaline, clouded with brown and gray; cell 1st *M*₂ long and relatively narrow; male hypopygium with the spines of the rostral prolongation of the ventral dististyle long and straight, black, the outer about two-thirds of the inner; dorsal dististyle obtuse at apex.

Male. Length about 6–6.3 mm.; wing, 7–7.8 mm.

Female. Length about 6 mm.; wing, 8.2–8.3 mm.

Rostrum obscure yellow, the palpi black. Antennæ dark brown, the scapal segments somewhat paler; flagellar segments short-oval. Head gray, paler behind and beneath; anterior vertex broad.

Anterior lateral pretergites yellowish. Mesonotum chiefly gray, the praescutum with three darker gray stripes, the broader median stripe more distinct; median region of scutum and the scutellum paler, more yellowish gray. Pleura gray, with darker longitudinal areas on the anepisternum and sternopleurite. Halteres yellow, the knobs infuscated. Legs with the coxæ and trochanters yellow, the fore coxæ a trifle darker; femora yellow, the tips narrowly and weakly infumed; remainder of legs passing gradually into brown, the tips of the individual tarsal segments narrowly blackened. Wings whitish subhyaline, with a handsome brown and gray clouding; stigma brown, oval, more or less connected with a large cloud at the end of *Rs*; cord and outer end of cell 1st *M*₂ more narrowly seamed with brown; extensive but paler gray washes on the median veins beyond the cord, as a seam at near midlength of the basal section of *Cu*₁, and the entire distal section of the same vein; similar extensive pale gray clouds on both anal veins; veins brownish yellow, darker in the clouded areas. Venation: *Sc*

short, Sc_1 ending before origin of R_s , Sc_2 a short distance from its tip; R_s relatively short and arcuated, about one-half longer than the more strongly arcuated basal section of R_{4+5} ; cell 1st M_2 relatively long and narrow; $m-cu$ close to the fork of M .

Abdominal tergites obscure yellow, darker medially and caudally, the surface somewhat pruinose; sternites brown; hypopygium large, the ventral dististyle conspicuously orange-yellow. Male hypopygium with the tergite transverse, the caudal margin with a broad U-shaped emargination. Ventral dististyle very large and fleshy, the rostral prolongation stout, beyond the spines more narrowed, terminating in a chitinized point; rostral spines unusually long and conspicuous, black, nearly straight and directed strongly basad; outer spine about two-thirds the length of the inner, both exceeding in length the prolongation itself. Dorsal dististyle strongly curved, widened at near midlength, the tip obtuse. Gonapophyses with the mesal apical lobe long and slender, gently curved.

HABITAT: Argentina. *Holotype*, ♂, Quebrada "Volcan," at Agua Amarilla, Catamarca, January 29, 1922 (V. Weiser). *Allotopotype*, ♀. *Paratopotypes*, 5 ♂♂, with the types.

I dedicate this interesting crane-fly to the memory of the late Engineer Vladimir Weiser, to whom I am very greatly indebted for many Andean Tipulidæ, chiefly from Jujuy, Tucuman and Catamarca. Among the described regional species, *L. weiseriana* is most closely allied to *L. (D.) invalida* Alexander (Peru), differing especially in the more extensive pattern of the wings and the details of structure of the male hypopygium.

***Limonia (Rhipidia) inæquipunctinata* sp. n.**

Belongs to the *maculata* group; antennæ (♂) elongate, the flagellar segments tripectinate, one of the branches being very reduced, the other two long and slender; antennæ bicolorous; thoracic pleura gray with two narrow longitudinal brown stripes; wings gray with a sparse brown pattern; male hypopygium with the rostral prolongation of the ventral dististyle very long and slender, with two long curved spines placed far out toward the outer end; phallosome large and complicated in structure.

Male. Length about 5 mm.; wing, 6.6 mm.

Rostrum and palpi black. Antennæ (♂) elongate, if bent backward extending to some distance beyond the base of the abdomen; scape dark; basal enlargements of all segments and branches black, the elongate pedicel of the flagellar segments with the exception of the last white; first flagellar segment with a single basal branch that is about as

long as the pedicel; flagellar segments two to eleven with two very long basal branches, in addition to a small intermediate branch that is about as long as the basal enlargement; longest branches about two and one-half times the segment, clothed with a delicate pubescence; outer face of basal enlargements of segments with very long, conspicuous verticils that are subequal to the segments; terminal flagellar segment elongate, with verticils that are a little shorter than the segments. Head dark gray

Pronotum dark brown. Mesonotal praescutum light brown, with indications of three dark stripes near the suture; posterior sclerites of mesonotum chiefly dark-colored. Pleura gray with two narrow dark brown longitudinal stripes. Halteres yellow, the knobs dark brown. Legs with the coxæ yellow, their bases dark brown; trochanters light yellow; remainder of legs broken. Wings gray, with a sparse brown pattern; cell *C* infuscated; cell *Sc* variegated with brown; stigma oval, grayish brown; vague brown clouds at origin of *Rs*, confluent with a spot at end of *Sc*; a large area at fork of *Rs*, confluent with the stigma; pale seams along cord and outer end of cell *1st M*₂; brown seams in outer ends of cells *R*₂ and *R*₃; prearcular region white; veins dark brown, *Cu* chiefly yellow. Conspicuous macrotrichia on veins beyond cord. Venation: *Sc* relatively long, extending to about opposite midlength of *Rs*, *Sc*₂ at its tip; *Rs* angulated at origin; cell *1st M*₂ small; *m-cu* shortly before the fork of *M*

Abdominal tergites obscure yellowish testaceous, the lateral margins narrowly, the caudal margins more broadly, infuscated; sternites yellow, the incisures darkened; outer segments darkened. Male hypopygium with the caudal margin of the tergite only gently emarginate. Basistyle with the ventro-mesal lobe long and slender, the apex a little expanded, provided with long conspicuous setæ; an additional series of powerful setæ along the margin. Ventral dististyle large and fleshy, with sparse inconspicuous setæ; rostral prolongation very long and conspicuous, the cephalic margin fimbriate with short dense yellow setæ; just before the apex with two long, slender, gently curved spines that are placed so close together as to appear almost as a single structure; immediately distad of the rostral prolongation, on the same face, the dististyle is produced into a pale conical fleshy lobe that is tipped with two or three elongate setæ. Dorsal dististyle a very long slender chitinated rod, strongly bent near midlength, the tip suddenly narrowed into a long straight spine. Gonapophyses pale, the mesal apical lobe elongate. Phallosome very large and complex in structure, including a pale fleshy central portion that is subtended by smaller fleshy lateral lobes.

HABITAT: Argentina. *Holotype*, ♂, Iguazu Falls, October 3-5, 1927, (R. & E. Shannon). Type in the United States National Museum.

The tripectination of the flagellar segments marks the extreme tendency, so far as at present known, in the tribe Limoniini.

***Limonia (Rhipidia) bruchiana* sp. n.**

Belongs to the *maculata* group; allied to *subcostata* Alexander; antennæ (σ) with eleven long-branched segments; mesonotum chiefly light brown, the dorso-pleural region extensively blackened; halteres black, the base of stem and apex of knob conspicuously yellow; wings whitish subhyaline, with an extensive gray pattern, most evident as a series of five costal areas; axillary region extensively whitened; *m-cu* before fork of *M*; male hypopygium with the tergite small, transverse; rostral prolongation of ventral dististyle long, decurved, the two spines very small and stout.

Male. Length about 7 mm; wing, 6.5 mm.; antenna, about 3.3 mm

Rostrum black, about one-half the length of the remainder of the head; palpi brownish black. Antennæ (σ) long and conspicuous, nearly half the length of the body, as shown by the measurements; scapal segments black; flagellar segments with the stems pale yellow, the branches black, the terminal segments dusky on outer half; antennæ 14-segmented, the formula being 2+11+1; all flagellar segments except the last long-bipectinate; branches of first flagellar segment subequal to the segment; of succeeding segments becoming gradually longer, the longest (about flagellar segments six to eight) more than twice the segment; flagellar segment eleven with the branches about one-half longer than the segment. Head dark gray; eyes (σ) above contiguous for a short distance.

Pronotum and anterior lateral pretergites restrictedly yellow. Mesonotal praescutum with the stripes light yellowish brown, the margins and interspaces narrowly margined with black; scutal lobes dark brown, the median area and scutellum more testaceous; postnotal mediotergite dark brown, paler caudally, the cephalo-lateral angles pale yellow, most of the surface in an oblique light slightly pruinose. Pleura brown, the dorsal region chiefly occupied by a conspicuous black longitudinal stripe. Halteres black, the base of the stem and apex of each knob conspicuously light yellow. Legs with the coxæ brownish yellow, darker basally; trochanters obscure yellow; femora brownish yellow, at or immediately before the tips with a dark brown ring; tibiae brown; tarsi dark brown; posterior tarsi broken beyond the basitarsus, the latter brownish yellow; it is highly probable that the succeeding tarsal segments of the posterior legs are similarly yellow, as in other members of the *subcostata* subgroup. Wings whitish subhyaline, with an extensive gray or brownish gray pattern, somewhat heavier along the costal region where there are five major areas, the last being the stigma, these areas much more extensive than the interspaces; similar dark seams along the cord and outer end of cell 1st *M*₂; basal axillary region conspicuously white; veins brown, the subcostal interspaces and vein *Cu*₁ more yellowish. Venation: *Sc*₁ ending about opposite three-fifths the length of *Rs*, *Sc*₂ at its tip; cell 1st *M*₂ relatively

small, shorter than vein M_4 beyond it; $m-cu$ about one-fourth its length before the fork of M .

Abdomen brown, the incisures somewhat darker. Male hypopygium with the tergite small, transverse, the caudal margin nearly straight, without setæ except two or three on lateral portions of sclerite. Basistyle with the ventro-mesal lobe large, strongly narrowed at apex, terminating in a powerful seta; mesal margin of basistyle with two powerful fasciculate setæ, the more cephalic one prolonged into a delicate hair-like point. Ventral dististyle with the rostral prolongation long, gently decurved and narrowed to the apex which bears a powerful terminal seta; rostral spines two, very short and stout, slightly separated, placed before midlength of the prolongation.

HABITAT: Argentina, Paraguay. *Holotype*, ♂, La Plata, Argentina, August 8, 1922, in room at light (Carlos Bruch). *Allotype*, ♀, Villarica, Paraguay, September, 1928, (F. Schade). *Paratypes*, 1 ♂, 1 ♀, with the allotype, September-November, 1928, (F. Schade).

I take great pleasure in naming this handsome *Rhipidia* in honor of the collector, my friend and colleague, Dr. Carlos Bruch. It is well-distinguished from *subcostata*, which seems certainly to be its nearest ally among the described species, by the coloration and details of structure.

***Limonia (Rhipidia) pallatangæ* sp. n.**

Belongs to the *uniseriata* group; general coloration yellow, the mesonotal praescutum with a median dark brown stripe; antennæ black, the penultimate segment yellow, flagellar segments one to ten with a single branch; pleura with two narrow longitudinal brownish black stripes; halteres black, the apices of the knobs yellow; wings creamy-yellow, with a conspicuous brown and gray clouded pattern; abdomen yellow, the hypopygium concolorous; male hypopygium with the spines of the rostral prolongation of the ventral dististyle short and spike-like.

Male. Length about 6.5 mm.: wing, 8 mm.

Rostrum and palpi black, the former about one-half the length of the head. Antennæ black, the base of the first segment a little brighter, the penultimate segment light yellow; axes of the outer segments becoming paler, almost whitish; antennæ with ten branched segments, the branches being single, the longest (about flagellar segment four or five) a little longer than the segment; branch of the first segment appearing merely as a stout spur that is about as long as the glabrous apical pedicel of the segment. Head brownish gray, clearer gray on the posterior orbits.

Mesonotal praescutum brownish yellow laterally, the disk chiefly occupied by reddish brown, the median stripe passing into dark brown; scutum and scutellum pale yellow, each scutal lobe traversed by a dark brown line that passes into the scutellum, converging toward a central point; postnotum with the median area darkened, the lateral margins pale. Pleura yellow, the surface largely covered by two narrow longitudinal brownish black stripes. Halteres black, the base of the stem pale yellow, the apices of the knobs obscure yellow. Legs with the coxae yellow, more or less darkened basally; trochanters yellow; femora yellowish brown to brown, the tibiae and tarsi yellow, the terminal tarsal segments darkened. Wings with the ground-color creamy-yellow, the surface largely covered by extensive brown and gray clouds, including a costal series of about six of the former, these more extensive than the interspaces; broad brownish gray seams along the cord, outer end of cell 1st M_2 and as marginal clouds at ends of some of the longitudinal veins; the paler gray areas occupy most of the remaining surface of the wings, including streaks near the outer ends of the marginal radial and medial cells; axillary region pale; veins yellow, darker in the infuscated areas. Venation: Sc_1 ending just beyond midlength of Rs , Sc_2 at its tip; Rs long, gently arcuated; free tip of Sc_2 a short distance beyond R_2 ; $m-cu$ close to fork of M .

Abdominal tergites brownish yellow, the sternites brighter yellow, the basal segments narrowly margined laterally with black lines; hypopygium yellowish. Male hypopygium with the tergite transverse, the caudal margin gently emarginate, the broad lobes with conspicuous setae. Ventral dististyle with the spines of the rostral prolongation placed beyond midlength, small, spike-like, close together. Dorsal dististyle gently curved, more expanded near outer end, terminating abruptly in an acute spine.

HABITAT: Ecuador. *Holotype*, ♂, Pallatanga, altitude 4400 feet, April 1, 1922 (G. H. H. Tate).

The only allied regional species is *L. (R). unipectinata* (Williston) which has all details of coloration of the wings and legs distinct.

***Limonia (Rhipidia) paraguayana* sp. n.**

Belongs to the *domestica* group; general coloration brownish yellow, the thorax variegated with brown; postnotal mediotergite with a velvety-black triangular area; legs yellow, the outer tarsal segments darkened; wings pale yellow, dotted with brown and gray; male hypopygium with the spines of the rostral prolongation of the ventral dististyle long and slender.

Male. Length about 5.5 mm.; wing, 6.8 mm.

Rostrum and palpi black. Antennae with the scapal segments brownish black, the flagellum extensively pale yellow, the central portion of each flagellar segment a trifle infuscated, the incisures thus

remaining broadly pale; flagellar segments (σ) almost simple, little if any produced. Head dark brownish gray; anterior vertex reduced to a linear strip.

Mesonotal praescutum chiefly pale brownish yellow, with a broad brown median stripe that becomes darker and better delimited on the posterior half of the sclerite; indications of narrow lateral brown stripes before the suture; scutal lobes extensively dark brown, ringed with brownish black; median area of scutum and the scutellum pale yellowish gray; postnotal mediotergite with a large black triangle on anterior half, the caudal and lateral portions of the sclerite pale. Pleura chiefly pale brownish yellow, narrowly lined ventrally with dark brown. Halteres pale yellow. Legs with the coxæ chiefly pale, the bases traversed by a narrow dark brown line; trochanters yellow; remainder of legs yellow, only the outer tarsal segments darkened. Wings pale yellow, with an abundant brown and gray dotting in all the cells; the more conspicuous brown areas are small and restricted, distributed as follows: Above the arculus; at supernumerary crossvein in cell Sc ; origin of Rs ; tip of Sc ; stigma; along cord and outer end of cell $1st\ M_2$; the gray dots are scattered in all cells, variable in size, some very small, others larger and tending to become confluent; veins pale, darker in the infuscated areas. Venation: A supernumerary crossvein in cell Sc ; Sc_1 ending about opposite midlength of Rs , Sc_2 at its tip; $m-cu$ before the fork of M .

Abdominal tergites chiefly brownish, the sternites paler, more yellowish, narrowly lined laterally with black; hypopygium yellow. Male hypopygium with the tergite transverse but relatively wide, narrowed outwardly, the caudal margin very gently emarginate. Ventral dististyle of moderate size, fleshy, the rostral prolongation long and conspicuous, with two or three long, gently curved spines, in the type there being three such spines on one style and only two on the other; the spines are placed shortly before the outer end of the prolongation, the innermost a little the shorter, the longest spine approximately two-thirds the length of the prolongation alone.

HABITAT: Paraguay. *Holotype*, σ , Villarica, July 15, 1928 (F. Schade).

L. (R.) paraguayana is most closely allied to *L. (R.) shannoni* (Alexander) of Eastern North America, which differs especially in the structure of the male hypopygium, the spines of the rostral prolongation of the ventral dististyle being short and stout.

***Limonia (Rhipidia) schadei* sp. n.**

Belongs to the *domestica* group; general coloration of thorax dark brown, the praescutum obscure yellow with a brown median stripe; antennal segments (σ) a little produced; wings saturated brownish yellow, sparsely patterned with brown;

stigma pale, encircled by a dusky ring; abdominal tergites bicolorous.

Male. Length about 6–6.4 mm.; wing, 7.2–7.7 mm.

Rostrum and palpi black. Antennæ black, the apical pedicels of the flagellar segments white; flagellar segments strongly produced, so the base of each segment appears triangular. Head blackish gray; eyes above contiguous or virtually so.

Pronotum brownish black. Mesonotal praescutum obscure yellow with a median brown stripe; scutal lobes infuscated, the center of each lobe obscure yellow; median region of scutum whitish testaceous; scutellum dusky, pale posteriorly; postnotum dark brown. Pleura chiefly dark brown, sparsely pruinose, the ventral pleurites abruptly pale. Halteres obscure yellow, the knobs weakly infuscated. Legs with the coxæ yellow, the bases dark brown; trochanters yellow; femora yellow, with a scarcely indicated darker subterminal ring; tibiæ and tarsi obscure yellow, the latter passing into dark brown. Wings saturated brownish yellow, the outer radial cells a little more infuscated; stigma pale, encircled by a dusky ring; narrow or restricted brown seams at origin of *Rs*, fork of *Sc*, along cord and outer end of cell *1st M*₂; posterior prearcular cells and axillary region dusky; veins dark brown, *C*, *Sc*, most of *R*, *Cu* and the *Anal* veins except at tips yellow. Venation: *Sc*₁ ending just beyond midlength of *Rs*, *Sc*₂ at its tip; cell *1st M*₂ relatively small; *m-cu* just beyond the fork of *M*.

Abdominal tergites bicolorous, yellow, the caudal and lateral portions narrowly dark brown; subterminal segments more extensively darkened; hypopygium obscure yellow; sternites chiefly pale yellow. Male hypopygium with the tergite transverse, the caudal margin very gently emarginate. Ventral dististyle with the rostral prolongation conspicuous, the two spines unusually long and prominent, nearly as long as the prolongation itself, gently curved and directed slightly basad.

HABITAT: Paraguay. *Holotype*, ♂, Santa Barbara, September 4, 1925 (F. Schade). *Paratype*, ♂, Villarica, June 30, 1925 (F. Schade).

I take great pleasure in dedicating this crane-fly to the collector, Mr. F. Schade, to whose efforts we owe most of our knowledge of the Tipulidæ of Paraguay. *L. (R.) schadei* is allied to *domestica* (Osten Sacken) being separated especially on the uniformly darkened, more strongly pectinate antennal flagellum, the body-coloration, and the structure of the male hypopygium.

***Limonia (Geranomyia) austroandina* sp. n.**

Belongs to the *canadensis* group; allied to *argentinensis* (Alexander); male hypopygium with the caudal margin of the tergite deeply notched; rostral spines of ventral dististyle

arising from very long, conspicuous swollen bases, especially the inner spine, the base of which is approximately twice as long as that of the outer spine.

Male. Length (excluding rostrum) about 6 mm.; wing, 7 mm.; rostrum about 4.3 mm.

Female. Length (excluding rostrum) about 7.5 mm.; wing, 6.8 mm.; rostrum about 4 mm.

Rostrum elongate, as shown by the measurements, dark brown, more yellowish at base. Antennæ with the scapal segments brownish yellow, the flagellum dark brown. Head gray, the posterior vertex and occiput broadly obscure yellow.

Mesonotal praescutum gray, largely covered by four darker plumbous-gray stripes, the humeral region more yellowish; remainder of mesonotum dark gray, the scutellum obscure yellow, the median region of the scutal lobes obscure brownish yellow. Pleura reddish brown, pruinose. Halteres pale, the knobs infuscated. Legs with the coxæ and trochanters reddish yellow; femora obscure yellow, the tips narrowly dark brown; tibiae obscure yellow, the tips even more narrowly darkened; tarsi passing into dark brown. Wings subhyaline, the oval stigma brown; veins brown. Venation: Sc_1 ending opposite midlength of Rs , Sc_2 at its tip; a weak supernumerary crossvein in cell Sc ; Rs arcuated to weakly angulated at origin; $m-cu$ at or before the fork of M , subequal to the distal section of Cu_1 .

Abdominal tergites dark brown, the caudal margins of the segments narrowly and restrictedly pale; sternites more yellow, the outer segments darkened. Male hypopygium with the tergite transverse, the caudal margin with a deep V-shaped median notch, the lobes with numerous conspicuous setæ. Basistyle of moderate size, the ventro-mesal lobe large, with a smaller fleshy lobule near base. Dorsal dististyle a slender, very strongly curved hook, gradually narrowed into a long slender tip. Ventral dististyle very large and fleshy; rostral spines long and conspicuous, the outer arising from a long basal tubercle, the inner spine arising from a very long pale cylindrical tubercle that is about twice as long as the base of the outer spine; both spines slender, the outer a trifle the longer. Gonapophyses with the mesal apical lobe produced into a long narrow blade that is longer than the length of the base of the apophysis.

HABITAT: Argentina. *Holotype*, ♂, Cienega, near Agua Amarilla, Catamarca, altitude 3000 meters, February 12, 1923 (V. Weiser). *Allotopotype*, ♀, with the type.

L. (G.) austroandina is quite distinct from the allied and generally similar *L. (G.) argentinensis* (Alexander), in the peculiar modifications of the male hypopygium, as described.

Shannonomyia Alexander.**Shannonomyia argenticeps** sp. n.

General coloration pale brownish yellow; antennæ with the basal three segments light yellow, the remainder dark brown; head silvery; legs yellow; wings fulvous-yellow, with a restricted brown pattern appearing as dark seams to the cross-veins and deflections; R_2 at fork of R_{3+4} .

Female. Length about 5.5 mm.; wing, 5.8 mm.

Rostrum and palpi dark brown. Antennæ (♀) short, the first three segments pale yellow, the succeeding segments abruptly dark brown; flagellar segments oval, gradually decreasing in size outwardly, the verticils a little longer than the segments. Head almost covered by a dense silvery pruinosity, the genæ more yellowish.

Mesonotum pale brownish yellow, without dark markings, the surface very vaguely pruinose. Pleura somewhat more testaceous yellow. Halteres obscure yellow. Legs with the coxæ and trochanters yellow; remainder of legs yellow, only the outer tarsal segments a little darker. Wings with a strong fulvous-yellow tinge, the prearcular and costal regions clearer yellow; very restricted brown seams at origin of R_s , on R_2 , along cord and outer end of cell 1st M_2 ; a whitish marginal spot at apex of cell R_4 ; veins yellow, darker in the infuscated areas. Venation: Sc pale, both Sc_1 and Sc_2 ending before the fork of R_s , the latter short, angulated at origin; R_2 at fork of R_{3+4} ; veins R_3 and R_4 strongly diverging, cell R_3 at margin more than twice R_2 ; cell 1st M_2 long, gently widened outwardly, longer than vein M_3 beyond it; $m-cu$ close to midlength of cell 1st M_2 .

Abdomen yellowish brown. Tergal valves of ovipositor long and slender, acicular, gently upcurved.

HABITAT: Ecuador. *Holotype*, ♀, Ventura, altitude 1400 feet, April 11, 1922 (G. H. H. Tate).

Shannonomyia argenticeps is very distinct from the numerous regional species of the genus.

Shannonomyia paraguayensis sp. n.

General coloration buffy brown, sparsely pruinose; legs and halteres yellow; wings yellowish, the stigma very pale brown; veins yellow; Sc_2 at extreme tip of Sc_1 ; abdominal tergites dark brown, the ninth segment yellow; male hypopygium with the outer dististyle unusually short and stout.

Male. Length about 5.5 mm.; wing, 6 mm.

Rostrum and palpi black, the former pruinose. Antennæ with the scapal segments brownish yellow, the basal flagellar segments light

brown, the outer segments passing into black; flagellar segments oval, with elongate verticils. Head light gray.

Pronotum brownish gray. Mesonotum buffy brown, the praescutum with the median region somewhat darker, the surface sparsely pruinose; pseudosutural foveæ very small, comma-shaped. Pleura buffy, the anepisternum darker. Halteres pale. Legs with the coxæ and trochanters yellow; remainder of legs obscure yellow, only the outer tarsal segments restrictedly darkened. Wings with a strong yellow suffusion, the oval stigma very pale brown; veins yellow. Venation: Sc_1 ending about opposite two-thirds the length of Rs , Sc_2 at its extreme tip; Rs strongly arcuated at origin; cell $1st\ M_2$ widened outwardly; $m-cu$ about one-half its length beyond the fork of M .

Abdominal tergites dark brown; basal sternites obscure yellow, narrowly infuscated laterally; outer sternites dark brown; ninth segment yellow; remainder of hypopygium dark brown. Male hypopygium with the outer dististyle unusually short and stout, widened beyond midlength, the apex with two blackened teeth, the outer shorter and more slender. Inner dististyle short, gently curved.

HABITAT: Paraguay. *Holotype*, ♂, Villarica, July 28, 1925 (F. Schade).

In its general appearance, *Shannonomyia paraguayensis* is most similar to *S. lentina* (Alexander) and *S. lentoides* (Alexander), of Middle America. It is very different in appearance from other regional species.

Atarba Osten Sacken.

Atarba (Atarba) brevicornis sp. n.

General coloration yellow; antennæ (♂) relatively short, bicolorous; legs yellow, the terminal tarsal segments darkened; wings light yellow; Sc short; $m-cu$ before the fork of M ; subterminal segments of abdomen (♂) extensively blackened; male hypopygium with the median region of the tergite produced into a conspicuous depressed rectangular lobe that divides into two divergent horns; aedeagus large.

Male. Length about 5 mm.; wing, 5.5 mm.

Rostrum obscure yellow, the palpi dark brown, the basal segment pale. Antennæ (♂) unusually short for this sex, if bent backward extending about to the base of the halteres; scapal segments yellow; basal flagellar segments bicolorous, the basal portion yellow, the remainder dark brown; on the first segment, the yellow equals the brown in amount; on succeeding segments the yellow decreases in area, on about the eighth flagellar segment becoming obsolete, the outer segments uniformly darkened; basal flagellar segment cylindrical, the outer segments long-oval. Head brownish yellow.

Mesonotum yellow, the postnotum slightly whitish pruinose. Pleura brownish yellow, the surface sparsely pruinose. Halteres pale. Legs yellow, the femoral tips not darkened, the tarsal segments beyond the first dark brown. Wings light yellow; stigma lacking; veins brighter yellow. Macrotrichia of veins shorter and less conspicuous than in *ficbrigi*. Venation: Sc_1 ending opposite the origin of R_s ; R_s relatively short, angulated at origin; anterior branch of R_s relatively short, cell R_4 at margin being unusually wide, more than twice R_2 ; basal section of R_5 straight, about three-fourths the length of R_s ; cell 1st M_2 small; $m-cu$ before the fork of M , the distance equal to one-third or one-fourth $m-cu$.

Abdomen obscure yellow, the tergites more or less darkened medially; a broad brownish black subterminal ring involving segments six to eight and the caudal portion of five; hypopygium yellow. Male hypopygium with the median region of the sternite produced into a conspicuous depressed long-rectangular lobe, the apex of which is further split into two divergent horns. Outer dististyle moderately slender, the teeth relatively small and scattered. Gonapophyses large and not especially spinous. Aedeagus large, constricted before mid-length, with a ridge-like collar immediately basad of this.

HABITAT: Paraguay. *Holotype*, ♂, Villarica, February 12, 1926 (F. Schade).

Atarba brevicornis is distinct from all of the numerous species of the genus in Tropical America. It agrees with *megaphallus* Alexander (Brazil) in the large size of the aedeagus but in the coloration of the antennæ agrees better with *ficbrigi* Alexander. (Paraguay) and similar species, from all of which it differs most evidently in the unusually short antennæ of the male sex.

***Atarba (Atarba) tatei* sp. n.**

General coloration brownish yellow; antennal flagellum uniformly brownish black; legs yellow, the tips of the femora narrowly and conspicuously blackened; wings grayish yellow, the stigma small and only slightly darker than the ground-color; R_s very short, about two-thirds the basal section of R_5 ; cell 1st M_2 short and nearly square; abdominal tergites dark brown, the basal segments weakly bicolorous; hypopygium yellow, the outer dististyle with only a few coarse spines on outer margin.

Male. Length about 5 mm.; wing, 6 mm.

Female. Length about 5.5 mm.; wing, 6.8 mm.

Rostrum light brownish yellow, the palpi darker brown. Antennæ with the basal segments of the scape dark brown, the second segment

paler; flagellum brownish black, the segments gradually decreasing in length and diameter outwardly, the terminal segment shorter and paler than the others; verticils of all except the outer segments shorter than the segments. Head chiefly infuscated.

Mesonotum brownish yellow, unmarked, the pleura more testaceous yellow. Halteres pale, the knobs slightly infuscated. Legs with the coxæ and trochanters yellow; femora yellow, the tips narrowly but conspicuously blackened; tibiæ and tarsi yellow, the outer segments of the latter darkened. Wings grayish yellow, the costal region clearer yellow; stigma, small oval, only a little darker than the ground-color; veins brownish yellow. Venation: Sc_1 ending shortly before R_s , the latter very short, about two-thirds the length of the basal section of R_s and in alignment with it; cell 1st M_2 unusually short and nearly square; $m-cu$ shortly beyond the fork of M .

Abdomen with the basal tergites weakly bicolorous, the remainder dark brown, especially the subterminal segments; hypopygium yellow; basal sternites clear pale yellow. Male hypopygium with the outer dististyle unusually slender and attenuated, the spines along the outer margin large and coarse, especially the three intermediate ones; beyond this point, the apex is slender, blackened, bearing a lateral spine close to tip. The sternal plate is broader than long.

HABITAT: Ecuador. *Holotype*, ♂, Pallatanga, altitude 4400 feet, April 1, 1922 (G. H. H. Tate). *Allotopotype*, ♀, March 26, 1922. *Paratopotype*, ♂, with the allotype.

The species is named in honor of the collector. By my key to the American species of *Atarba* (Ann. Ent. Soc. America, 19:171; 1926), this species runs to *brunneicornis* Alexander (Colombia), a very different species that has the femora uniformly yellow and the details of venation distinct.

Gnophomyia Osten Sacken.

Gnophomyia pallidapex sp. n.

General coloration black, the lateral angles of the pronotal scutellum yellow; wings blackish, the outer cells extensively paler; R_{2+3+4} and R_{2+3} subequal; $m-cu$ beyond midlength of the long cell 1st M_2 ; abdomen, including the hypopygium, black.

Male. Length about 6 mm.; wing, 6 mm.

Female. Length about 7 mm.; wing, 6.2 mm.

Rostrum and palpi black. Antennæ black throughout, relatively elongate (♂), if bent backward extending to beyond the base of the abdomen; flagellar segments elongate-oval. Head black, the anterior vertex a little dusted with gray.

Thorax entirely black with the exception of the lateral angles of the pronotal scutellum which are yellow. Halteres and legs entirely black.

Wings with a strong blackish tinge, the cells beyond the level of the outer end of cell *1st M*₂, as well as the outer ends of the cubital and anal cells conspicuously paler; veins black. Venation: *Rs* short, very gently arcuated, in alignment with *R*₅; *R*₂₊₃ subequal to *R*₂₊₃₊₁ and equal to or only a little shorter than *R*₁₊₂; veins *R*₃ and *R*₄ nearly parallel, diverging very gradually; cell *1st M*₂ elongate, with *m-cu* beyond midlength; veins issuing from the cell rather elongate.

Abdomen, including hypopygium, black. Male hypopygium with the tergite large, its caudal margin nearly transverse, fringed with setae. Outer dististyle long and slender, glabrous, gently curved to the obtuse apex. Inner dististyle very short, the tip enlarged and obtuse, the stem with long conspicuous setae, some of which virtually equal the style in length.

HABITAT: Paraguay. *Holotype*, ♂, Santa Barbara, October 17, 1925 (F. Schade). *Allotopotype*, ♀. *Paratype*, ♂, Molinasque, Department of Caragua, November 9, 1925 (F. Schade).

Gnophomyia pallidapex is very distinct from the known Neotropical species of the genus in the peculiar coloration of the wings.

Gonomyia Meigen.

Gonomyia (*Progonomyia*) *pleurolineata* sp. n

General coloration* yellowish, the dorsal pleura striped longitudinally with dark brown; wings grayish yellow, the stigma barely evident; *R*₂ very faint to subobsolete, placed just before the fork of *R*₃₊₄; *m-cu* shortly before the fork of *M*; male hypopygium with the outer dististyle having the dilated blackened head trilobed.

Male. Length about 5.3 mm.; wing, 6.3 mm.

Rostrum pale, more brownish pruinose above; palpi black. Antennae with the basal segment obscure yellow; second segment black, the base paler; flagellum black, the segments long-oval with verticils that do not exceed the segments. Head gray, the center of the vertex a little infuscated.

Anterior lateral pretergites light sulphur-yellow. Mesonotal praescutum dark, pruinose, more intense in front, the humeral region light sulphur-yellow; posterior sclerites of mesonotum more yellowish, especially the scutellum. Pleura yellow, striped longitudinally with darker, including a broad dorsal darker brown stripe; sternopleurite weakly darkened ventrally. Halteres pale, the knobs slightly darkened. Legs with the coxae brownish yellow, the fore coxae more darkened; trochanters yellow; femora obscure yellow, the tips somewhat darker; tibiae yellowish brown; tarsi passing into dark brown. Wings grayish yellow, the stigma barely evident; veins brown. Venation: *Sc* long, *Sc*₁ ending beyond midlength of the long gently arcuated *Rs*, *Sc*₂ some

distance from its tip, Sc_1 alone about one-half longer than $m-cu$; R_2 very faint to subobsolete, placed just before the fork of R_{3+4} ; cell 2nd M_2 deep; $m-cu$ shortly before the fork of M .

Abdomen yellowish brown, the hypopygium somewhat brighter. Male hypopygium with the outer dististyle distinctly trifid, the enlarged blackened head being divided into two pincer-like major arms, one flattened and obtuse, the other more curved and terminating in a blackened subacute point; besides these, at their bases, a shorter more triangular branch or lobe. Inner dististyle arcuated beyond base, the distal portion smooth, the apex obtusely rounded, the surface without punctures. Apex of aedeagus weakly trifid.

HABITAT: Argentina. *Holotype*, ♂, Quebrada "Volcan," at Agua Amarilla, Catamarca, January 29, 1922 (V. Weiser).

Gonomyia pleurolineata is readily told from all allied species by the coloration of the body and wings and the structure of the male hypopygium. The only other regional species so far described with a tripartite outer dististyle is *G. weiseri* Alexander, an otherwise very different fly.

***Gonomyia (Gonomyia) catamarcæ* sp. n**

Allied to *G. andicola* Alexander; general coloration of mesonotum yellowish brown; rostrum yellow; antennæ entirely blackened; halteres elongate, dusky; wings grayish, the stigma poorly defined; petiole of cell R_3 elongate; $m-cu$ before the fork of M ; male hypopygium with the outer dististyle a simple rod, the apex truncated; phallosome with the apophyses symmetrical, slender, each bifid at apex.

Male. Length about 5 mm.; wing, 6.4 mm.

Rostrum yellow; palpi dark brown. Antennæ black, the first segment a trifle brightened at base; antennæ relatively long for a member of this genus, if bent backward extending nearly to the wing-root. Head pale, shrunken in the type, the vertex apparently infuscated.

Anterior lateral pretergites whitish yellow. Mesonotum light yellowish brown, without distinct markings, the scutellum a trifle more yellow. Pleura chiefly pale yellow, with a vague dusky area extending from the propleura onto the anepisternum; sternopleurite more reddish yellow. Halteres elongate, dusky. Legs with the coxæ and trochanters pale yellow; femora pale brown, brighter basally, the tips darker brown; tarsi dark brown. Wings rather strongly narrowed at base, grayish, the stigma very pale; veins brown, Sc more yellowish. Venation: Sc , ending just beyond the origin of Rs , Sc_2 an equal distance before this origin; Rs almost in alignment with R_1 , the basal section of the latter obliterated or nearly so; petiole of cell R_3 elongate, gently arcuated, nearly twice vein R_3 ; cell 1st M_2 long-rectangular, subequal to vein M_4 beyond it; $m-cu$ about one-half its length before the fork of M .

Abdominal tergites brownish yellow, indistinctly lined longitudinally with brown, most evident medially; sternites pale yellow; hypopygium yellow. Male hypopygium with the tergite produced medially into a lobe that divides into divergent arms. Basistyle with a relatively small, elongate-oval dusky lobe. Outer dististyle a long, pale, fleshy structure, the outer surface and apex with setæ. Inner dististyle a simple, nearly straight-rod, the basal half more dilated, the outer margin with numerous setæ, including two powerful flattened ones; distal portion of style narrow, straight, the apex truncated, before the tip with a single powerful seta. Phallosomè long and slender, the aedeagus extending slightly beyond the subtending apophyses, the latter symmetrical, elongate, each split into two acute spines at tip.

HABITAT: Argentina. *Holotype*, ♂, Bolson, Catamarca, altitude 2700 meters, March 7, 1924 (V. Weiser).

The only allied species so far made known is *G. (G.) andicola* Alexander (Colombia), which differs in the dark coloration, the venation, and structure of the male hypopygium.

Molophilus Curtis.

Molophilus substylifer sp. n.

Belongs to the *plagiatus* group; closely allied to *M. stylifer* Alexander, differing especially in the wing-shape, venation, and details of structure of the male hypopygium.

Male. Length, excluding head, about 3 mm.; wing, 3.5 mm.

Head broken. General coloration of mesonotum light brown, variegated with darker brown, the postnotum dark brown. Pleura chiefly dark. Halteres obscure yellow, the knobs weakly darkened. Legs with the coxæ brownish yellow; trochanters yellow; femora yellow basally, more infuscated outwardly; tibiæ and tarsi passing into brown. Wings whitish subhyaline, the veins conspicuous, brown; prearcular and costal regions more yellowish. Wings broader than in *stylifer*, the caudal margin opposite the anal veins not concave, as in the latter species. Venation: R_{2+3} more oblique in position; vein 2nd *A* longer, ending about opposite the caudal end of vein *m-cu*.

Abdomen brown, the hypopygium somewhat brighter. Male hypopygium with the basistyle having the terminal beak relatively slender, without a basal shoulder, as in *stylifer*. Outer dististyle with both arms subequal in length and subacute at tips; in *stylifer*, the lateral arm is much shorter and truncated. Basal dististyle a long straight rod that narrows to an acute point, the short lateral spine placed at or slightly beyond one-third the length.

HABITAT: Argentina. *Holotype*, ♂, Bolson, Catamarca, altitude 2750 meters, March 9, 1924 (V. Weiser).

The antennæ of the male of *Molophilus stylifer* are unusually elongate; the condition in the present species is unknown.

***Molophilus pallatangensis* sp. n.**

Belongs to the *plagiatus* group; allied and generally similar to *M. perseus* Alexander, differing especially in the coloration and wing-pattern.

Male. Length about 3.5-3.7 mm.; wing, 4.5-4.7 mm.

Rostrum and palpi dark brown. Antennæ (♂) of moderate length, if bent backward extending nearly to the root of the halteres; scapal segments dark, the flagellum brownish yellow; flagellar segments subcylindrical, with a short dense white pubescence. Head dark gray.

Posterior pronotum pale yellow. Mesonotum dark brownish gray, the humeral region of the praescutum brighter yellow. Pleura dark gray. Halteres pale yellow, the base of the stem and the knobs lighter yellow. Legs with the coxæ and trochanters testaceous yellow; femora obscure yellow, darker outwardly; tibiæ and tarsi darker brown. Wings whitish subhyaline, the veins darker, conspicuously seamed with brown clouds to produce a more or less streaked appearance, the more evident seams being along the cord and along the main veins basad of the cord; veins pale yellow, somewhat darker in the clouded areas. Macrotrichia pale brown, the long costal fringe and conspicuous patches along the cord and on veins *Cu* and *2nd A* darker brown and more conspicuous. Venation: Almost as in *perseus*; vein *2nd A* extending to slightly beyond *m-cu*.

Abdominal tergites brownish black, the sternites more obscure yellow; hypopygium dark brown. Male hypopygium with the beak of the basistyle simple, the base relatively stout. Basal dististyle generally similar to that of *perseus*, appearing as a strong rod that is extended into a powerful apical spine, the outer margin provided with a series of ten or more spines, the basal ones shorter and appressed, the outer ones longer and more erect.

HABITAT: Ecuador. *Holotype*, ♂, Pallatanga, altitude 4400 feet, March 28, 1922 (G. H. H. Tate). *Paratopotypes*, 2 ♂♂, March 26-28, 1922 (G. H. H. Tate).

The thorax of the type of *M. perseus* was described as being light yellowish brown but a paratype female in my collection is much darker, more grayish brown. It seems possible that more than a single species is confused in the series. *M. pallatangensis* differs most evidently in the conspicuously patterned wings, with dark veins and patches of dark macrotrichia.

***Molophilus paraguayanus* sp. n.**

Belongs to the *plagiatus* group; general coloration brownish gray; antennæ brownish black; male hypopygium with the basal dististyle broadly expanded on basal two-fifths, the

mesal edge with abundant appressed spinous setæ, the apical portion abruptly narrowed into a slender spine.

Male. Length about 3.5–3.6 mm.; wing, 4.3–4.4 mm.

Female. Length about 4.2 mm.; wing, 4.5 mm.

Rostrum and palpi black. Antennæ (♂) brownish black, of moderate length, if bent backward extending about to the wing-root. Head brownish gray.

Mesonotum brownish gray, the anterior lateral pretergites and restricted humeral region light sulphur-yellow; pseudosutural foveæ elongate, dark-colored. Pleura darker brown, the dorso-pleural region pale. Halteres yellow, the knobs weakly infumed. Legs with the coxæ testaceous yellow, the fore coxæ somewhat darker; trochanters yellow; femora obscure yellow, the outer ends darkened; tibiae and tarsi dark brown. Wings tinged with brown, the costal region brighter, more yellowish; veins brown, the macrotrichia still darker brown. Venation: R_2 lying shortly beyond the level of $r-m$; vein 2nd A ending just before the outer end of $m-cu$.

Abdomen dark brown, the sternites in male weakly bicolorous, obscure yellow with the caudal margins narrowly dark brown, in the female more uniformly darkened; hypopygium dark. Male hypopygium with the apical beak of the basistyle slender, blackened. Basal dististyle with about the basal two-fifths greatly expanded, the mesal edge with abundant appressed spinous setæ, the apical portion abruptly narrowed into a slender spine. Aedeagus sinuous.

HABITAT: Paraguay. *Holotype*, ♂, Villarica, February 1, 1925 (F. Schade). *Allotopotype*, ♀, June 10, 1925. *Paratopotypes*, 1 ♂, with the allotype; 1 ♀, with the type.

Molophilus paraguayanus is very distinct from all species in the structure of the male hypopygium.

INDEX TO VOLUME XXII.

- Abbott, Cyril E., article by, 331.
 Absolute Humidity in Insect Cold
 Hardness, 601.
Akermes cordae, 45.
Alapus, 86.
 Alexander, Charles P., article by, 768.
 Allen, H. W., article by, 676.
Allomerus 8-articulatus, 38.
Amphorophora gerani, 473.
Amphicephalus, 96.
Ana junius, 297.
Ancylicha fenestrata, 190.
Andrena (*Trachandrena*) *rodecki*, 755.
 forbesi, 756.
 indianensis, 757.
 multiplicata, 756.
 obscura, 757.
 spiraeana, 756.
Andrenosoma chalybea, 284.
 acuna, 286.
 crassa, 285.
 quadrinuculata, 285.
 varipes, 284.
 Andrews, E. A., article by, 369.
Anisolabis, 638.
Anisolabis annulipes, 638.
Anuraphis ornata, 3.
 chrysothamnicola, 5.
 debricornis, 10.
 flocculosa, 7.
 senecioradicis, 9.
Apanteles diatraea, 630.
Aphelinus jucundus, 440.
Aphelinus mali, 341.
Aphelinus Mali and its Travels, 311.
Aphicendyrtus inquisitor, 445.
 Aphididae, New, From Colorado, 1.
 Aphididae, New, From Colorado, 468.
 Aphididae, Pemphigini in Utah, 251.
Aphis laciniaria, 15.
 asterensis, 22.
 cercocarpi, 17.
 fraseræ, 16.
 lupini, 18.
 ribiensis, 20.
 pentstemonicola, 23.
 phaceliae, 26.
Aphroptera biroi, 190.
Arachnomorphæ, 521.
Asaphes americana, 449.
Asilidae of Cuba, 272.
Asilinae, 286.
Asilus bullatus, 288.
 loewi, 289.
Atarba, 781.
 brevicornis, 781.
 tatei, 782.
Atomosia incisularis, 280.
 cerverai, 282.
 maestrae, 282.
 metallica, 283.
 parva, 281.
 pubescens, 281.
 ramsdeni, 289.
 similis, 282.
Azteca sp., 36, 38, 39, 40, 45, 50, 60.
 alfari, 38.
 cecropiae, 50.
 longiceps, 36, 37, 38, 50, 53, 54.
 trigona, 42.
Baccha bromleyi, 490.
 carlota, 491.
 macgregori, 492.
 Baerg, W. J., article by, 161.
 Bald-Faced Hornet, The, 659.
Bassus stigmaterus, 633.
 Beamer, R. H., article by, 115.
 Bequaert, J., article by, 555.
Birch Case-Bearer, Immature Stages
 of, 480.
Blepharepium annulatum, 279.
 Book Notices, 135, 426, 488, 554, 582,
 620, 730, 758.
 Braggia, 28.
Braggia echinata, 29.
 Breaker, E. P., article by, 459.
 Bromley, S. W., article by, 272.
 Brooklyn Entomological Society, 392.
 Campbell, F. L., article by, 401.
Camponotus sp., 60.
Campsurus signis, 67.
Cardiococcus, 230.
Caseola, 522.
Casigneta, 190.
Ceronema, 231.
Ceroplastes, 231.
Ceroplastodes, 232.
Cerotaima laticipes, 279.
Chaetopsis fluvifrons, 638.
Cheilosis versicolor, 496.
Cicadellidae, New South American, 465.
Cissococcus, 233.
Clycollecanum, 56.
Coccidae, Generic Classification of, 197.
Coccinea, 39.

- Coccus, 39, 222.
 Coccus bromeliæ, 34.
 elongatus, 39.
 hesperidum, 39.
 Cockerell, T. D. A., article by, 754.
 Coleophora salmani, 480.
 Coleoptera from Bait-traps, 427.
 Colorado Aphididæ, 1.
 Crane Flies from South America, 768.
 Crematogaster sp., 36, 37, 60.
 atra, 38.
 corrina, 38.
 Criorhina excavatus, 498.
 pallidipes, 498.
 spinitarsis, 499.
 Cryptes, 233.
 Cryptocellus barberi, 593.
 emarginatus, 592.
 foedus, 595.
 magnus, 589.
 manni, 591.
 simonis, 596.
 Cryptocerus sp., 48.
 Cryptostigma, 48, 234.
 Cryptostigma biorhynchus, 48.
 quinquepori, 50.
 reticulolaminæ, 51.
 secretus, 53.
 Ctenizidæ, 511.
 Ctenochiton, 234.
 Cyclolecanium hyperbaterum, 56.
 Cyrtopholis bartholomei, 519.
 Curran, C. H., article by, 489.

 Dasypogonina, 275.
 DeLong, D. M., and Sleesman, J. P.,
 article by, 81.
 Deltacephalus, Subgeneric Revision, 81.
 Deltocephalus, 97.
 Deltocephalus comesus, 104.
 Deromyia bilineata, 278.
 ternata, 278.
 Despoina submutica, 193.
 Dexodes nana, 506.
 Dietrich, Henry, (and Frost, S. W.),
 article by, 427.
 Doru lineare, 638.
 Dragonflies, Rearing of From Eggs, 651.
 Dryopidæ, Larval Structure, 691.
 Dryopinæ (Helichus), 694.
 Dryopinæ (Lara?), 695.
 Dunavan, David, article by, 731.

 Ecpanteria, List of Species and
 Revision, 310.
 Ecpanteria, List of Published Figures,
 328.
 Ecpanteria detecta dorsata, 324.
 chelifer, 326.
 Elbenia nigrosignata, 191.

 Elimaea bakeri, 189.
 filicauda, 189.
 kraussi, 189.
 poaeifolia, 189.
 Elminæ, 700, 701.
 (Elmis quadrinotatus), 703.
 (Macronychus?), 704.
 (Stenelmis), 697.
 Elmis maugei aenea Mull, 706.
 Engelhardt, George P., article by, 392.
 Entomological Sentiment, 335.
 Erax brunnescens, 291.
 cubensis, 292.
 nigritarsis, 290.
 pilosulus, 292.
 portoricensis, 290.
 rufitibia, 292.
 stylatus, 291.
 Eriococcus, New Species of, from
 Mississippi, 762.
 Eriococcus pilosus, 763.
 smithi, 764.
 Eriopeltis, 235.
 Eristalis Arbustorum L., Respiratory
 Organs of, 731.
 Erythroneura, New Species, 115.
 Erythroneura anfracta, 123.
 ancora, 122.
 aprica, 122.
 bipunctata, 121.
 canyonensis, 120.
 carmini, 121.
 casta, 118.
 cimarroni, 119.
 coloradensis, 122.
 gilensis, 122.
 grandis, 127.
 illinoensis, 125.
 kiperi, 124.
 milleri, 125.
 nicholi, 121.
 obscura, 117.
 pallenta, 117.
 pinalensis, 119.
 regalis, 125.
 rubicunda, 126.
 texana, 121.
 triceroprocta, 118.
 tricolor, 124.
 tripunctata, 119.
 unicolor, 120.
 variabilis, 126.
 Essig, E. O., article by, 335.
 Eucalymnatus, 224.
 Euponera gilva harnedi, 543.
 Eurypelma marxi, 517.
 Euscelis stactogalus, 130.
 Ewing, H. E., article by, 583.
 Exaeretopus, 228.

- Farinococcus multispinosus*, 38.
Filippia, 235.
Flexamius, 82.
Flexamius surculus, 99.
 Folded-Winged Wasps of the Bermudas, 555.
 Forbes, Wm. T. M., article by, 310.
Formica Exsectoides F., Mound Building Ant, 369.
 Frost, S. W., and Dietrich, Henry, article by, 427.
Geranium Aphid, Parasites of, 438.
 Gillette, C. P., and Palmer, M. A., articles by, 1, 468.
Gnophomyia, 783.
 pallidapex, 783.
 pleurolineata, 784.
 catamarcae, 785.
 Griswold, Grace H., article by, 438.
Gryllacrids and *Tettigomids*, Javanese, 175.
Gryllacridæ, 175.
Gryllacrinæ, 176.
Gryllacris africana, 176.
 caudelli, 185.
 evanida, 179.
 ferruginea, 181.
 fuscifrons, 184.
 fuscinervis, 179.
 griffine, 183.
 lineolata, 183.
 macilentia, 182.
 melanocrania, 177.
 menzeli, 183.
 personata, 185.
 ruficeps, 182.
 signifera, 184.
 si-rambeica, 183.
 translucens, 176.
 Hallock, Harold C., article by, 246.
Hebecephalus, 91.
 Height and Silking, Factors Influencing Corn Borer Population, 528.
Hemilecanium, 236.
Holochlora paradoxa, 191.
 signata bogoriensis, 192.
 Honeybee, Variation and Correlation in, 168.
 Howard, L. O., article by, 142.
 Howard, L. O., article by, 341.
 Huber, L. L. (and Neiswander, C. R.) article by, 527.
 Hungerford, H. B., article by, 759.
Idiotettix, 465.
Idiotettix magnificus, 465.
 boliviana, 466.
 brunneus, 467.
 fasciatus, 466.
Inghisia, 237.
 Insect Chitin, Detection and Estimation of, 401.
 Insular Wasp Faunæ, 555.
Iris Borer, *Macronoctua Onusta*, Natural Enemies of, 459.
 Johnson, Charles W., article by, 131.
 Karny, H. H., article by, 175.
Kermesidæ, 762.
 Knowlton, George F. (and Maxon), article by, 251.
Korinchia sinensis, 503.
 Krull, Wendell H., article by, 651.
Lachnus similis, 30.
 medispinosus, 30.
Laevicephalus, 92.
Laevicephalus cicatrix, 102.
 orbiculus, 103.
 subrutilus, 103.
Laphriinæ, 279.
Latalus, 87.
 Lawson, Paul B., article by, 130.
 Leafhopper Parasite—*Polynema*, 130.
Lecanium, 225.
Lecanopsis, 237.
Lecon, 639.
Leptogaster obscuripes, 273.
 cubensis, 274.
 venustus, 274.
Leptogastrinæ, 273.
Leptothorax pergandei flavus, 549.
 pergandei floridanus spinosus, 551.
 wheeleri, 547.
Lichtensia, 238.
Limonia, 769.
Limonia austroandina, 778.
 bruchiana, 774.
 catamarcana, 769.
 inaequipectinata, 772.
 pallatangæ, 775.
 paraguayana, 776.
 schadei, 777.
 villaricæ, 770.
 weiseriana, 771.
Linyphiidæ, 521.
Lixophaga diatraeæ, 622.
 Lobdell, Gladys Hoke, article by, 762.
Luzulaspis, 230.
Macronoctua onusta, Enemies of, 459.
Macrosiphum cornelli, 438.
 williamsi, 468.
 Malcomson, R. O., article by, 728.
Mallococcus, 238.
Mallophaga, New Species, 728.
Mallophora bruneri, 287.
 macquarti, 287.
Mallota salti, 499.

- Masicera senilis*, 462.
 Mayfly, *Campsurus segnis* Needham, 61.
 Maxon, Asa C., and Knowlton, George F., article by, 251.
Meconemina, 194.
 Medical Entomology, 136.
Mesembris platytarsius, 501.
 simplicipes, 500.
Mesolecanium, 39.
Mesolecanium inquilinum, 40.
Microneta aeronautica, 521.
Molophilus pallatangensis, 787.
 paraguayanus, 787.
 substylifer, 786.
Monomorium floricola, 639.
 Morgan, Ann H., article by, 61.
 Morrison, Harold, article by, 33.
 Mote, Don C., article by, 70.
Muscina assimilis, 461.
 meditabunda, 461.
 stabulans, 461.
 Muttkowski, R. A., article by, 552.
Mygalomorphæ, 511.
Myrmekiophila fluviatilis, 516.
Myrmicina, 546.
Myrsidea bonariensis, 728.
Myzus aquilegiæ, 30.
 essigi, 30.
 leucorini, 470.
 polemonii, 471.
Neolecanium, 40.
Neolecanium craspeditæ, 40.
 deramelæ, 43.
 Neiswander, C. R., and Huber, L. L., article by, 527.
 Nestling Birds and Protocalliphora, 131.
 New York Entomological Society, 392.
 Nutrition and Metabolism of Insects, 552.
Odynerus bermudensis, 578.
Ommatius marginellus, 286.
Onomarchus, 192.
 leuconotus, 192.
 mandarinus, 192.
 Osborn, Herbert, article by, 465.
Pachylomerus carabivorus, 511.
 Palmer, M. A. (and Gillette, C. P.), articles by, 1, 468.
Palus, 85.
Paracaedicia verrucosa, 190.
Parafairmairia, 229.
Paralecanium, 239.
 Parasites of the Geranium Aphid, 438.
 Payne, Nellie M., article by, 601.
Pemphigus betæ, 267.
 populi-caulis, 254, 258.
 populi-globuli, 261.
 populi-ramulorum, 266.
 populi-transversus, 263.
 populi-venæ, 264.
 Petrunkevitch, Alexander, article by, 511.
Philophedra, 229.
Philodromus setosus, 523.
Philopterus cristata, 729.
Physokermes, 240.
 Plank, H. K., article by, 621.
Plesiomma funnestum, 276.
 indecorum, 276.
 lineatum, 276.
 salti, 277.
Plocamaphis braggii, 1.
 Proceedings of the Twenty-third Annual Meeting, 144.
Pogonomyrax californicus barnesi, 546.
Polistes fuscatus, 576.
Polyamius, 88.
Polyamius aestuarium, 100.
 montanus, 101.
Polynema saga, 130.
Ponera opaciceps, 545.
Ponerina, 543.
Prenolepis, 639.
Prociphilus fraxinitolit, 270.
Proctacanthus vittatus, 293.
Prolabia unidentata, 638.
Prosenia scutellaris, 507.
 varia, 509.
 variegata, 509.
 zonalis, 508.
Protocalliphora, 131.
Protopulvinaria, 223.
Psephenina (*Psephenus*), 693.
Pseudococcina, 34.
Pseudococcus brevipipes, 34.
 maritimus, 36.
 probrevipes, 36.
 rotundus, 38.
 texensis, 38.
Pseudomyrma christopherseni, 36, 38.
 boxi, 38.
 gracilis, 39.
 sericea, 37, 50, 60.
 triplaridis, 38.
Pseudophyllus titan, 192.
Pseudopulvinaria, 239.
Psilota fasciata, 494.
Psyra melanonota, 191.
Pterophyllina, 192.
Pulvinaria, 226.
Pyrophorus, 639.
 Rau, Philip, article by, 659.
Rhaebelima, 189.
Rhaphidophorina, 188.
Rhaphidophora loricata, 188.
Rhingia lateralis, 496.
Rhopalogaster bella, 283.
Rhopalosiphum bossekia, 474.

- Ricinoides, 597.
 Ricinulei, Primitive Order of Arachnids, 583.
 Riley, William A., article by, 136.
- Saissetia, 224
 Saissetia auriculata, 54.
 hemisphaerica, 54.
 Salman, K. A., article by, 480
 Salpingogaster punctifrons, 493
 Sarcophaga cimbicix, 461
 helcis, 637.
 latisterna, 462
 pedata, 638
 sternodontis, 636.
 surrubea, 637.
 Sarcophaginae (Diptera), Rearing of, 246.
 Sathrophyllia femorata, 194.
 Scaphurinae, 189.
 Schwarz, Eugene Amandus, Necrology, 142
 Secopennis, 85
 Sericomyia completa, 502
 Shannonomyia argenticeps, 780
 paraguayensis, 780.
 Signosomopsis cronis, 505
 townsendi, 504
 Siphomatrophia grvida, 12
 Sleesman, J. P. (and DeLong, D. M.), article by, 81
 Smith, M. R., article by, 543.
 Soil Animals Injurious to Sugarcane Roots, 641.
 Solenopsis corticalis, 639
 Spencer, Herbert and Stracener, Charles L., article by, 641
 Sphageus chalcoproctus, 277.
 Spiders, American, 511
 Spiracles of Weevils, 331
 Steiner, Loren F., article by, 297.
 Stemweden, John Benjamin, article by, 197.
 Stracener, Charles L. (and Spencer, Herbert), article by, 641.
- Sugar Cane Moth Stalkborer, Natural Enemies of, in Cuba, 621.
 Sugar Cane Roots, Animals Affecting, 641.
 Syrphidae, 489
 Syrphidae, New, 489.
- Tachinidae of Mississippi, List of, 676.
 Tachinidae, New, 489.
 Takahashia, 240
 Tarantula, Cocoon-Making, 161.
 Tettigonidae, 189
 Thecabius populi-monilis, 250.
 conduphifolus, 252
 Thelia binaculata, 370.
 Theraphosidae, 517.
 Thomisidae, 523
 Tipula, 768
 colombicola, 768.
 Tipulidae, New South American, 768.
 Towneyella, 227.
 Trachandrena, Andrenidae, Bees of, 754.
 Tracheal Branches in Nymph of Anax, 279.
 Trichogramma minuta, 634
- Urypelmia californica, 161.
- Vanduzee arquata, 370.
 Vela from Arizona, New Species, Hemiptera, 759.
 Vela beameri, 759
 Vespa arenaria, 576.
 Vespa maculata, nesting habits, 659.
 Vinsonia, 241
 Volucella escomeli, 489.
- Warble Fly Hypoderma Bovis, Reproductive System, 70.
 West, Luther S., article by, 691.
- Xiphidiopsis picta, 194.

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